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APPENDIX F

ELECTROMAGNETIC INDUCTION
FOR
LATERAL WASTE EXTENT GEOPHYSICAL SURVEY

ELECTROMAGNETIC INDUCTION

The theory of electromagnetic induction is not new. The use of highly portable, reliable, and simple equipment to collect electromagnetic data is a recent development, however. The most commonly used equipment is manufactured by Geonics, Ltd. The Geonics EM-34XL is the instrument we will be using at the Delta Site. The EM-34XL requires two persons to operate.

The Geonics equipment operates by energizing a transmitter coil with an alternating current. The frequency of the alternating current is in the audio range. The current in the transmitter coil produces a primary magnetic field which induces current to flow in loops beneath the coil. These currrent loops generate a secondary magnetic field, the intensity of which is measured by the receiver console and coil.

The magnitude of the secondary magnetic field sensed by the receiver is a function of the intercoil spacing (distance between transmitter and receiver coils), operating frequency, and ground conductivity. Under certain conditions, such as those incorporated into the EM-34XL, this function is rather simple. In general, the ratio of the secondary to primary magnetic field is linearly proportional to the terrain conductivity. This makes it possible for the receiver to read directly in units of conductivity. The units of conductivity are milli-mhos per meter (mmhos/m) or milli-Seimens per meter (mS/m). This is the inverse of resistivity units, which are expressed as ohm-meters or ohm-feet. To convert conductivity values to resistivity values, divide the conductivity number into 1000. Thus, a conductivity value of 3 mmho/m is equivalent to a resistivity value of 33 ohm-meters or about 1100 ohm-feet.

The EM-34XL can make a total of six types of measurements. These correspond to intercoil spacings of 10, 20, and 40 meters in both the vertical and horizontal dipole configurations. Two types of readings, referred to as the vertical and horixontal dipoles, are made for each intercoil spacing. The dipole is an imaginary axis passing through the center of the coil perpendicular to the plane of the coil. Thus, if the coil is lying flat on the ground, it is in the vertical dipole mode. If the coil is standing up on end, it is in the horizontal dipole mode. This concept is illustrated in Figure 9.1.

The conductivity value measured by the receiver is termed the apparent conductivity. It is called apparent conductivity because it is a function of the conductivity distribution of earth materials below instrument. For example, at the Delta Landfill the earth changes character with depth going from soil to weathered bedrock to bedrock. Each of these materials has a different conductivity, but the meter only senses one conductivity value. This value is a complicated combination of all materials below the instrument.

In general, as the distance between the receiver and transmitter coils increases, the depth of investigation increases. The depth of investigation is the depth of investigation is the depth at which the apparent conductivity measured by the receiver is no longer affected by changes in earth ma rials. As a rule of thumb, the depth of investigation is 1.5 times the intercoil spacing for the vertical dipole configuration (coils flat on the ground) and 0.75 times the intercoil spacing for the horizontal dipole configuration. Thus, for the EM-34XL the depth of investigation ranges from 7.5 meters (10 meter horizontal dipole reading) to 60 meters (40 meter vertical dipole). The various depths of investigation for all readings are shown in Table 9.1.

It is apparent from Table and the previous discussion that there is a distinct difference between the vertical and horizontal dipole readings. Not only are the depths of investigation different, but the way in which subsurface materials contribute to the reading is different. The horizontal dipole reading is affected by near-surface materials more than by deeper materials. The

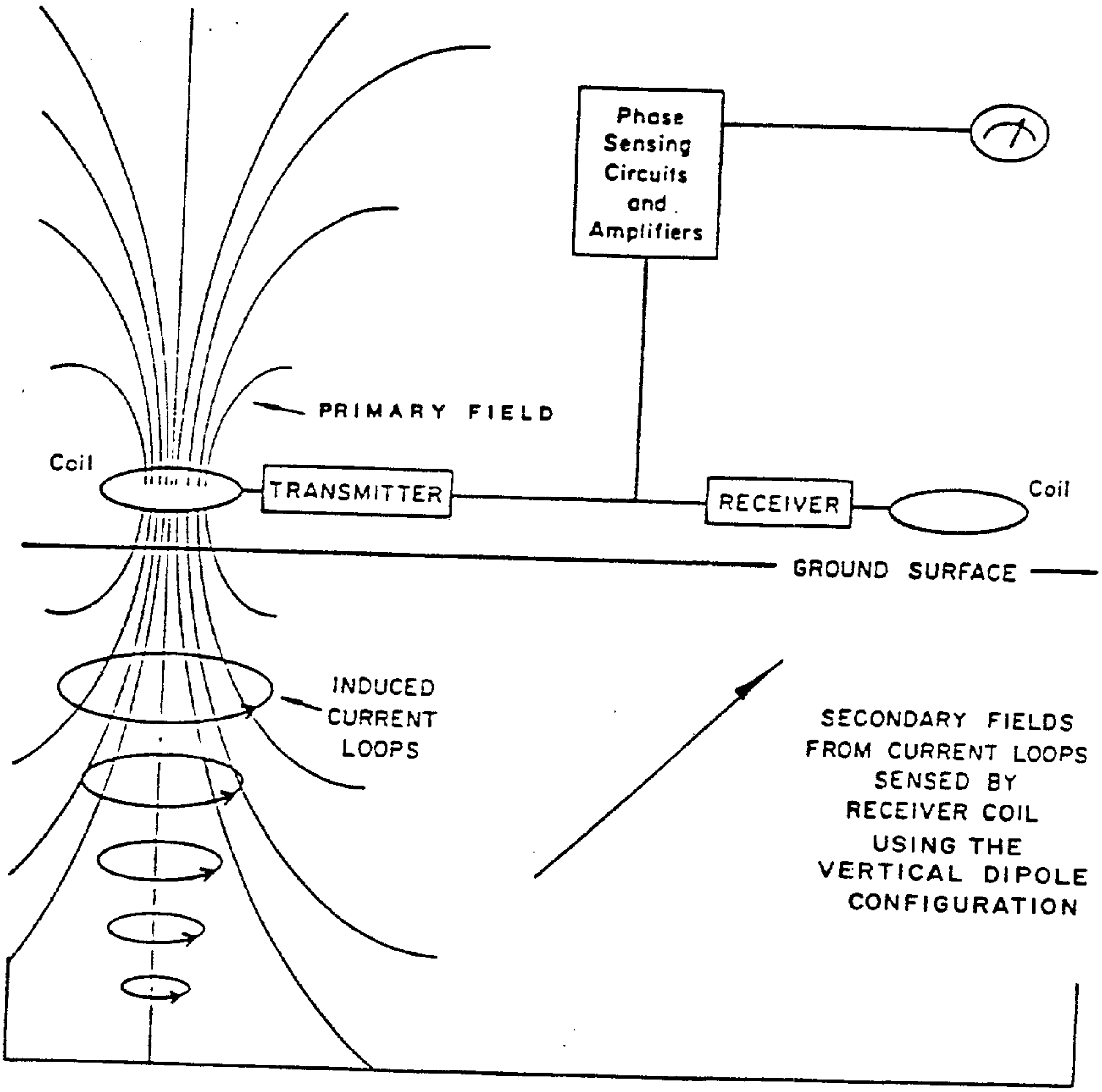

Figure 9.1. Diagram illustrating the operating principles of electromagnetic induction (modified from Benson et al., 1983).

Table 9.1. Approximate depths of investigation for the EM-34XL.

Intercoil Spacing (meters)	Exploration Depth in Meters (feet) Horizontal Dipoles	Vertical Dipoles
10	7.5 (25)	15.0 (50)
20	15.0 (50)	30.0 (100)
40	30.0 (100)	60.0 (200)

vertical dipole reading, on the other hand, is affected more by deep earth materials and is not affected by shallow materials.

Under ideal circumstances, where the water table is some distance below the land surface, the vertical dipole configuration would give the best results for groundwater studies because the overall apparent conductivity reading would be heavily weighted at or below the water table (in the potential contamination zone). Unfortunately, some human limitations prevent the vertical dipole from being as useful as it could be because the EM-34XL coils must be kept co-planar. Deviations from these conditions are not a problem with the horizontal dipole configuration, but can cause serious error in the vertical dipole orientation. Because of these potential use difficulties of the vertical dipole, it is generally good practice to use both the horizontal and vertical dipole in every investigation.

The relationship between the horizontal and vertical dipole readings and their respective weighting functions can be described mathematically. The weighting functions are illustrated graphically Figure 9.2. The horizontal weighting function has its maximum value at the land surface and decreases exponentially with depth. The vertical dipole, curve, on the other hand, has a value of zero at the surface, increases to its maximum value at a depth of about 1 percent of the intercoil spacing, and then decreases with depth.

The weighting functions shown in Figure illustrate that the horizontal dipole reading is very sensitive to changes in soil conductivity. Thus, changes in soil moisture can greatly affect apparent conductivity. The vertical dipole reading, on the other hand, in insensitive to soil conditions. This reading would be affected more by water-table fluctuations than the horizontal dipole reading.

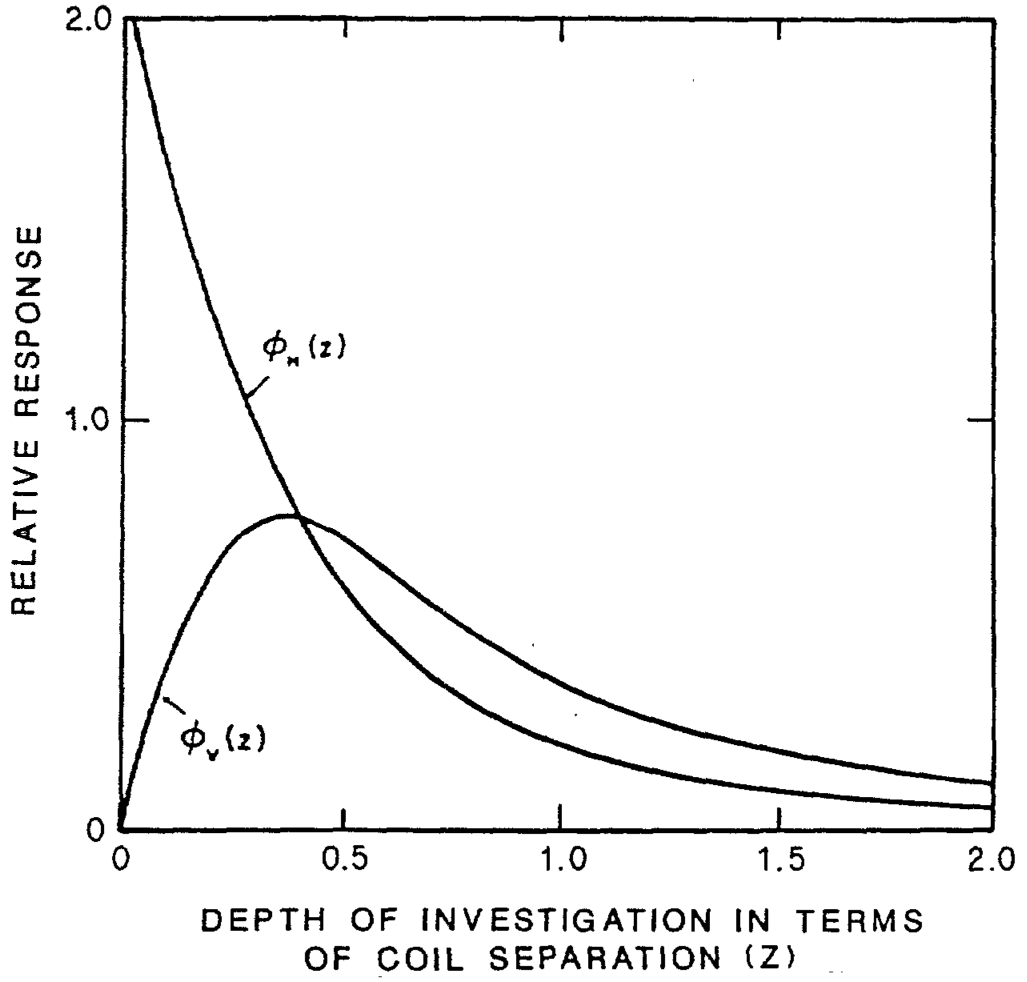

Figure 9.2. Weighting functions for the vertical and horizontal dipoles.

FACTORS AFFECTING APPARENT RESISTIVITY

Natural Influences

Rocks and minerals that make up the soil, unconsolidated material, and bedrock are insulators exhibiting a very high resistivity. There are exceptions to this rule, such as certain conductive minerals (magnetite, graphite, and pyrite) and clay. If these conductive minerals are not present the apparent conductivity or resistivity measured at the surface is determined by the following:

1. clay content, clay type
2. moisture profile with deth
3. moisture salinity
4. moisture temperature

Of these properties, the moisture profile with depth is the most complex as it describes the way in which the prorsity; the saturation; and the number, size, and shape of interconnecting passages all vary with depth. The moisture profile is affected by material typed, topography, compaction and season.

In practice, it is sufficient to be aware of a few key relationships when designing a geophysical survey or interpreting geophysical data. These can be summarized as follows:

1. Apparent conductivity is proportional to the fluid conductivity of soil or ground water.
2. Apparent conductivity is proportional to the degree of saturation of the soil and the height of the water-table in an unconfined aquifer.
3. Apparent conductivity is proportional to the degree of fracturing in a bedrock aquifer.
4. Apparent conductivity increases with the clay content of soil or rock.

The first relationship is the underlying reason wy EM are so widely used to trace groundwater contamination. Many forms of groundwater contamination raise the electrical conductivity of the groundwater. Even those contaminants that are not electrolytic such as organic compounds, are often associated with electrolytic chemicals. Because of these two facts, most forms of groundwater contamination have the potential to increase the apparent conductivity of the aquifer, but the measured effect is concentration dependent.

A good example of the effect of moisture content on EM readings was shown at a landfill site in Maryland. Data were collected along a portion of the EM perimeter traverse around a landfill prior to and after a significant rainfall event. The apparent conductivities for the 20 meter horizontal dipole configurations were plotted and the pre-rainfall readings exhibited the lowest apparent conductivities at each station, while the readings taken just after the rainfall were the highest. A third set of readings was taken one week after the rainfall event. The apparent conductivities were lower than immediately after the rain but had not returned to the pre-rainfall values. The cause of the elevated readings taken immediately after the rainfall was the increase in soil moisture content and a slight rise in the water-table.

The third relationship is one of the most important to consider when conducting a geophysical survey in fractured rack terrain. As the degree of fracturing increases, so does the apparent conductivity. When studying groundwater contamination in fractured rock, this relationship often causes a double anomaly. That is, the fractured zones are the main conduits of groundwater flow and thus contaminant transport. The contaminated groundwater associated with these zones increases the apparent conductivity still higher.

The final relationship, that increased clay content raises apparent conductivity, causes problems when conducting a geophysical survey in a sand and gravel aquifer. Clay lenses and beds are often associated with sand and gravel aquifers. Thus, a high conductivity anomaly encountered in a geophysical survey in these areas could be caused by a thick clay lens or by contaminated groundwater. There is really no way of telling, without good geologic control, i.e., drilling. The occurrence of clay lenses is not expected to be an issue at the Delta site as the geology is composed of weathered and unweathered bedrock.

Source of Interference

Em readings are affected not only by natural phenomena such as changes in soil moisture content, but also by man-made sources of interference. These interferences should be avoided where possible or their effects should be quantified. The three most common sources of interference are 1) power lines, 2) large metallic objects such as fences or buildings, and 3) buried utilities such as pipes and cables.

In area where the exact location of underground utilities is unknown, the EM readings can often be useful in locating these objects. When apparent conductivities exceed 30 to 50 mmho/m or the reading appears to be less than zero (called reversed polarity), a buried structure is indicated.

Knowledge of the location of interferences is important when designing a geophysical survey. If the geophysical data are collected in areas unaffected by man-made interferences, interpretation of the data will be much less troublesome.

REFERENCES

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APPENDIX G

OPERATING AND CALIBRATION PROCEDURES

OPERATING INSTRUCTIONS

OLYMPIC WELL PROBE

ACTAT CORPORATION
P.O. Box 5542 · Bellingham, Wa. 98227
(206) 676-9635

Olympi
WELL PRO

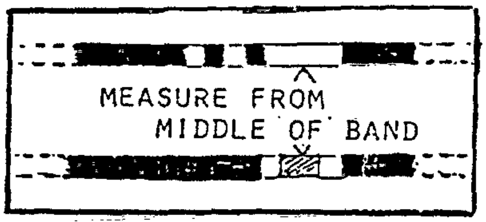
OPERATING INSTRUCTIONS

YOUR OLYMPIC WELL PROBE IS A PRECISION INSTRUMENT DESIGNED TO PROVIDE MANY YEARS OF RELIABLE SERVICE WHEN PROPERLY HANDLED AND MAINTAINED. KEEPING THE INSTRUMENT, CABLE AND ELEMENT CLEAN AND CAREFULLY STORED WHEN NOT IN USE AND REPLACING THE BATTERY ONCE A YEAR WILL FURTHER EXTEND THE RELIABILITY. ALTHOUG BATTERY LIFE SHOULD BE GOOD FOR A YEAR, HEAVY USAGE COULD REQUIRE EARLIER REPLACEMENT. THIS CAN BE ACCOMPLISHED BY REMOVING THE THREE SCREWS RETAINING T FACEPLATE. THE 9 VOLT BATTERY IS MOUNTED ON THE REVERSE SIDE.

CHECKING WATER LEVELS IS QUICK AND EASY WITH THE OLYMPIC WELL PROBE. ACCESS FOR LOWERING THE PROBE ELEMENT INTO A WELL CAN USUALLY BE GAINED THROUGH A VENT OR INSPECTION HOLE IN THE WELL SEAL. IF NO ACCESS IS AVAILABLE, THEN REMOVAL OF ONE RETAINING BOLT IN THE SEAL WILL PROVIDE ENTRY.

WITH THE SWITCH TO THE LIGHT OR BUZZER POSITION, THE ELEMENT IS LOWERED [illegible] THE WELL BY PULLING THE CABLE FROM THE HAND HELD REEL. THIS METHOD WILL PROVIDE THE NECESSARY "FEEL" AS THE ELEMENT DESCENDS AND WILL BETTER INDICATE ANY POSSI HANG-UP IN THE WELL CASING HARDWARE. WHEN THE WATER LEVEL REACHES THAT POINT JU ABOVE THE INSULATOR SLEEVE ON THE PROBE ELEMENT TIP, THE BUZZER OR LIGHT WILL INDICATE CONTACT. CABLE MEASUREMENTS ARE CALIBRATED FROM THAT JUNCTION POINT. MOVING THE ELEMENT TIP UP AND DOWN FRACTIONALLY, WHILE OBSERVING THE SELECTED INDICATOR, WILL LOCATE THE WATER LEVEL. COLORED BANDS ARE LOCATED AT FIVE FOOT INTERVALS AND ARE CODED AS FOLLOWS:

EACH WHITE = 10 FEET
EACH ORANGE = 50 FEET
EACH GREEN = 100 FEET
EACH BLUE = 500 FEET



EXAMPLE: ONE GREEN, ONE ORANGE, TWO WHITE = 170 FEET. INTERMEDIATE FIVE FOOT MARKS ARE SHOWN AS AN ORANGE BAND SUPERIMPOSED ON A WHITE BAND.

FOR WELL OWNERS AND THOSE RESPONSIBLE FOR MAINTAINING WATER WELL SYSTEMS, T PERIODIC RECORDING OF WATER LEVEL READINGS CAN PROVIDE VALUABLE INSIGHT FOR WATE SURVEYS AND USAGE PROGRAMS. BY PLOTTING THESE READINGS IN GRAPH FORM, SEASON TRENDS ARE CONVENIENTLY ILLUSTRATED AND PRUDENT WATER MANAGEMENT CAN BE INITIATE

OPERATION AND MAINTENANCE INSTRUCTIONS

SOIL TEST MODEL 0484

WATER LEVEL INDICATOR

DR-760A,DR-760AM,DR-76
DR-762AM
WATER LEVEL INDICATOR
MODEL
0484

Technical Data

SOILTEST®

2205 Lee Street • P.O. Box 931 • Evanston, Illinois 60204 U.S.A.
U.S. (800) 323-1242 • Illinois (800) 942-3374
(312) 869-5500 • Telex: 687-1537 SOILT UW

1. GENERAL

The DR-760A, DR-760AM & DR-762AM, Water Level Indicators are self contained, transistorized, battery operated instruments for determination of water level in bore holes and wells. No ground or outside power connections are needed. The units are mounted in rugged, convenient spool-type reel which is also used for cable handling. A high strength durable, coated cable that has black numerals every five feet (or two meters) facilites determination of depth.

The corrosion resistant probe with a stainless steel tip generates a weak voltage when immersed in water. This voltage is amplified through a transistorized circuit and is read directly on the meter.

The required power source is a 1 1/2 volt pen-light battery, with a button for the battery.

2. OPERATION

Turn power switch "ON". Lower probe into the wall or borehole until a sharp deflection is shown on the meter.

Read the wire marker to determine depth of probe at point of needle deflection and record.

NOTE: By lowering probe until cable begins to slack, the depth of well or borehole is determined. A subsidiary scale or rule with an available range of 5 ft. (or 2 meters) may be used to measure distance from ground level to first marking on the cable above ground. This distance should be subtracted from the first reading on cable above ground to obtain correct depth of water from ground level.

Model DR-760A is supplied with 300 ft. cable and DR-760AM with a 92 meter cable. Model DR-762A is supplied with 500 ft. cable and DR-762M with 152 meter cable.

3. MAINTENANCE - PROBE

Keeping probe clean will extend life of the unit. If it's necessary to change the probe, polarity must be maintained.

3.1 Cut cable at a point 2-3 inches above probe.

3.2 Ther will be two (2) wires in the cable.

3.3 Splice copper to copper and silver to silver, above the probe.

3.4 Solder and tape splices.

3.5 Consider (add or subtract) the splice length when making depth determinations.

3.6 To clean the probe of oil contamination, dip in dilute hydrochloric acid.

4. MODELS AVAILABLE

DR-760A	Water Level Indicator 300 feet.
DR-760AM	Water Level Indicator 92 meter.
DR-762A	Deep Probe Water Level Indicator 500 feet.
DR-762AM	Deep Probe Water Level Indicator 152 meter.

5. SPARE PARTS

5.1 Probes

DR-763A spare probe for DR-760A and DR-760M lead weighted probe and short length of attachment cable. Tip diameter .220".

DR-764A replacement probe and section, weighted and segmented. Similar to that on DR-762A. Can be used on DR-760A, DR-760M, DR-762A and DR-762M. Includes short length of attachment cable. Probe diameter .412".

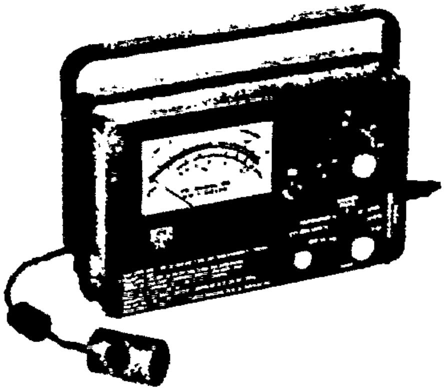
5.2 Replacement Cable - (Probes not included)

CALIBRATION, OPERATION AND MAINTENANCE INSTRUCTIONS

YSI MODELS 33 AND 33M

SPECIFIC CONDUCTANCE AND TEMPERATURE METER

YSI MODELS 33 AND 33M S-C-T METERS INSTRUCTIONS



GENERAL DESCRIPTION

The YSI Model 33 and 33M S-C-T Meters are portable, battery powered, transistorized instruments designed to accurately measure salinity, conductivity and temperature. They use a probe consisting of a rugged, plastic conductivity cell and a precision YSI thermistor temperature sensor combined in a single unit.

Conductivity with the Model 33 is expressed as micromhos/centimeter; with the 33M, it is millisiemens/meter (mS/m). These are measurements of the electrical conductance the sample would show if measured between opposite faces of a 1 cm cube. (Conversion information: 1 micromho/cm = 0.1 mS/m.) Salinity is the number of grams of salt/kilogram of sample (ppt = parts per thousand). This measurement assumes the sample contains a "standard" sea water salt mixture. The sample temperature is measured in degrees Celsius.

Salinity measurements are manually temperature compensated by direct dial. Conductivity measurements are not temperature compensated; however, a temperature function is provided on the instrument to aid with calculation of corrections. When temperature and conductivity are known, it is possible to calculate salinity; and when only temperature and salinity are known, it is possible to calculate conductivity. This is discussed in the secion on Recalibration.

SPECIFICATIONS

Model 33 Conductivity

Ranges: 0 to 500 (x1), 0 to 5,000 (x10), and 0 to 50,000 micromhos/cm (x100) with YSI 3300 Series Probes. (Note: The "micromho" designations on the meter are a shorthand form for "micromho/cm".)

Accuracy: (See Error Section)
±2.5% max. error at 500, 5,000 and 50,000 plus probe.
±3.0% max. error at 250, 2,500 and 25,000 plus probe.

Readability:
2.5 micromhos/cm on 500 micromho/cm range.
25 micromhos/cm on 5,000 micromho/cm range.
250 micromhos/cm on 50,000 micromho/cm range.

Temperature Compensation: None.

Model 33M Conductivity

Ranges:
0 to 50 (x1), 0 to 500 (x10), and 0 to 5,000 (x100) mS/m with YSI 3300 Series Probes.

Accuracy: (See Error Section)
±2.5% max. error at 50, 500, and 5,000 plus probe.
±3.0% max. error at 25, 250, and 2,500 plus probe.

Readability:
0.25 mS/m on 50 mS/m range.
2.5 mS/m on 500 mS/m range.
25.0 mS/m on 5,000 mS/m range.

Temperature Compensation: None.

Salinity

Range: 0-40 ppt in temperature range of -2 to +45°C, within specified conductivity range of 0 to 50,000 micromho/cm (0 to 5.000 mS/m). See chart in section on Recalibration.

Accuracy (See Error Section)
Above 4°C: ±0.9 ppt at 40 ppt and ±0.7 ppt at 20 ppt plus conductivity probe.

Below 4°C: ±1.1 ppt at 40 ppt and ±0.9 ppt at 20 ppt plus conductivity probe.

Readability: 0.2 ppt on 0-40 ppt range.

Temperature Compensation: Manual by direct dial from -2 to +45°C.

Temperature Range: -2 to +50°C.

Accuracy: ±0.1°C at -2°C, ±0.6°C at 45°C plus probe (See Error Section)

Readability: ±0.15°C at -2°C to ±0.37°C at 45°C.

Power Supply: Two D-size alkaline batteries, Eveready E95 or equivalent, provide approximately 200 hours of operation.

Instrument Ambient Range: -5 to +45°C. A maximum error of ±0.1% of the reading per °C change in instrument temperature can occur. This error is negligible if the instrument is readjusted to redline for each reading.

Scientific Division
Yellow Springs Instrument Co., Inc.
Yellow Springs, Ohio 45387 USA • Phone 513 767-7241 • Telex 205437

YSI 3300 Series Conductivity/Temperature Probe

Nominal Probe Constant: K = 5/cm (K = 500/m)

Accuracy: ±2% of reading for conductivity and salinity.

Error of ±0.1°C at 0°C and ±0.3°C at 40°C.

OPERATION

Setup

1. Adjust meter zero (if necessary) by turning the bakelite screw on the meter face so that the meter needle coincides with the zero on the conductivity scale.

2. Calibrate the meter by turning the MODE control to REDLINE and adjusting the REDLINE control so the meter needle lines up with the redline on the meter face. If this cannot be accomplished, replace the batteries.

3. Plug the probe into the probe jack on the side of the instrument.

4. Put the probe in the solution to be measured. (See Probe Use.)

Temperature

Set the MODE control to TEMPERATURE. Allow time for the probe temperature to come to equilibrium with that of the water before reading. Read the temperature on the bottom scale of the meter in degrees Celsius.

Conductivity

1. Switch to X100. If the reading is below 50 on the 0-500 range (5.0 on the 0-50 mS/m range), switch to X10. If the reading is still below 50 (5.0 mS/m), switch to the X1 scale. Read the meter scale and multiply the reading appropriately. The answer is expressed in micromhos/cm (mS/m). Measurements are not temperature compensated.

Example
Meter Reading: 247 (24.7 mS/m)
Scale: X10
Answer: 2470 micromhos/cm (247.0 mS/m)

2. When measuring on the X100 and X10 scales, depress the CELL TEST button. The meter reading should fall less than 2%; if greater, the probe is fouled and the measurement is in error. Clean the probe and re-measure.

NOTE: The CELL TEST does not function on the X1 scale.

Salinity

1. Determine the sample temperature and adjust the temperature dial to that value.

2. Switch to x100. If the reading is above 500 micromho/cm (50 mS/m), the salinity value is beyond the measurement range.

3. If the reading is in range, switch to SALINITY and read salinity on the red 0-40 ppt meter scale.

4. Depress the CELL TEST button. The fall in meter reading should be less than 2%; if it is greater, the probe is fouled and the measurement is in error. Clean the probe and re-measure.

Error

The maximum error in a reading can be calculated by using the graphs in the following sections.

Temperature Error

The temperature scale is designed to give the minimum salinity error when temperature readings are used to compensate salinity measurements.

Figure 1 shows total error for probe and instrument versus °C meter reading.

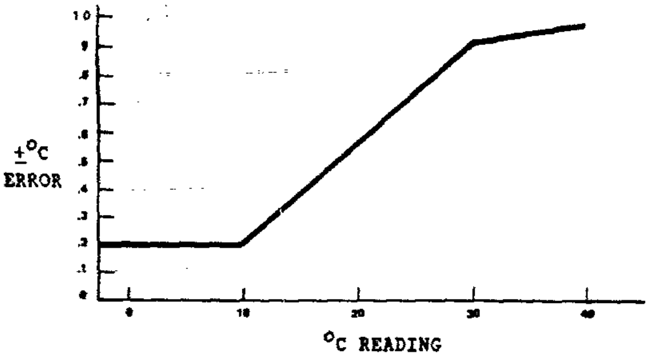


FIGURE 1

Example:
Meter Reading: 15°C
Total Error: 0.4°C
Accuracy: 15°C ±0.4°C for probe and instrument combined.

Conductivity Error

Figure 2 shows the worst-case conductivity error as a function of the conductivity reading for the probe and instrument combined.

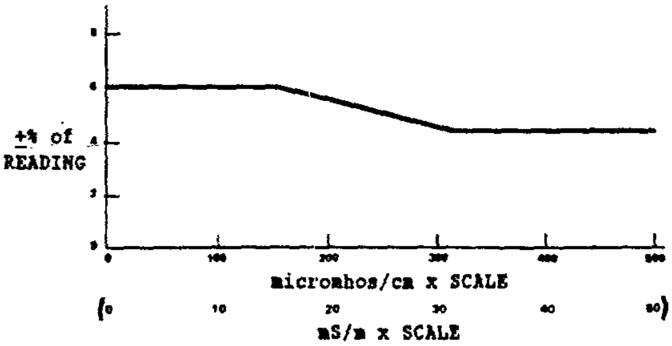


FIGURE 2

Example
Meter Reading: 360 micromhos/cm (36 mS/m)
Scale: X10
% Reading Error: ±4.5%
Accuracy: 3600 ±162 micromhos/cm (360 ±16.2 mS/m) for probe and instrument

Salinity Error

The salinity readings are a function of temperature and conductivity, therefore the accuracy is a function of both.

The temperature scale and temperature control have been designed to minimize the temperature error contribution to the salinity error. The error shown in Figure 3 is the total of the temperature and conductivity probe, the temperature scale and the salinity scale error.

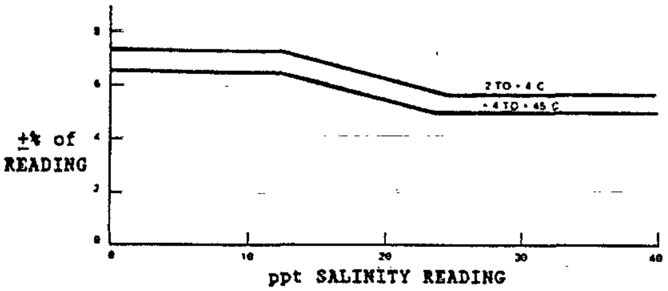


FIGURE 3

Example
Meter Reading: 10 ppt, @ 10°C
% of Reading Error: 6.5%
Accuracy: 10 ppt ±0.65 ppt for all errors, combined worst case.

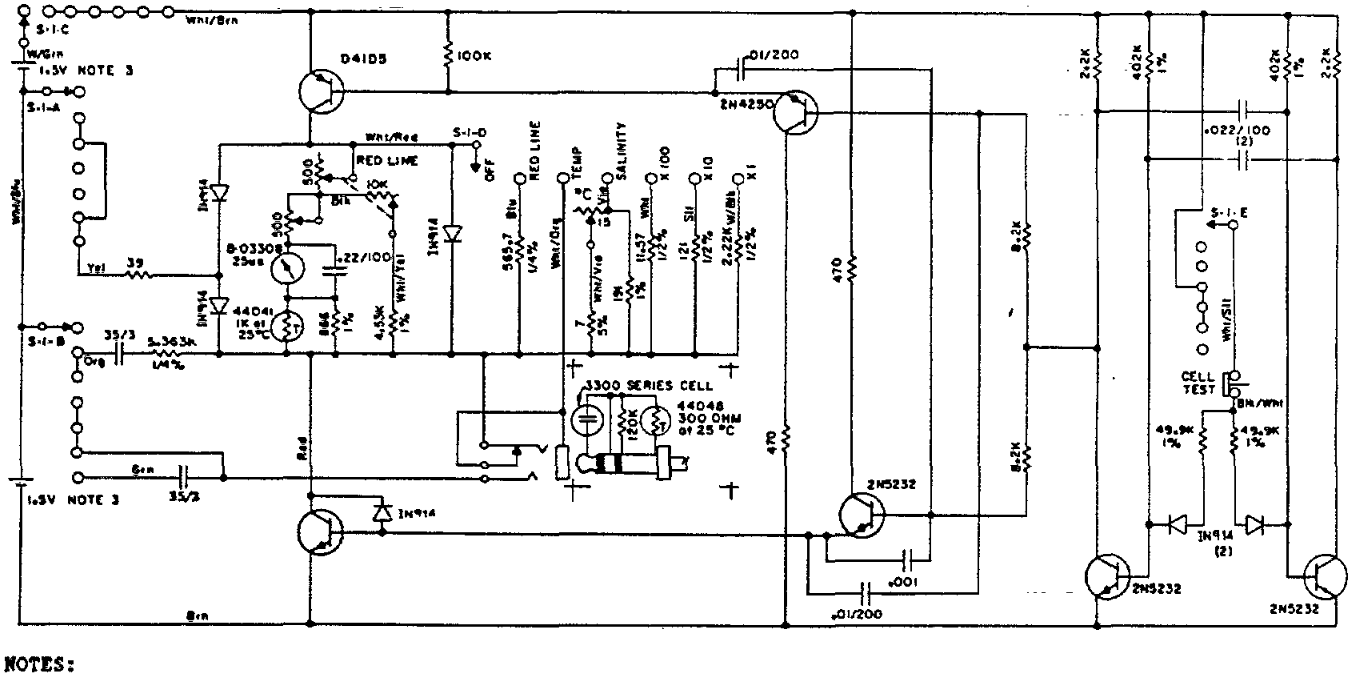
CIRCUIT DESCRIPTION

The circuit is composed of two parts; a multivibrator and switching transistors. The multivibrator produces a square waveform voltage. The square wave is applied to two switching transistors. They alternately apply two batteries of opposite polarity to the probe thus providing AC power which minimizes polarization effects. The meter is in series with one battery and measures the current from it. The current from the battery is proportional to the conductance of the cell. Salinity is measured in a special range conductivity circuit which includes a user-adjusted temperature compensator. In the temperature, redline and X1 positions, the multivibrator operates at 100Hz. In the salinity, X100 and X10 positions the multivibrator operates at 600Hz; in these ranges, pushing the CELL TEST button drops the frequency to 100Hz, allowing the operator to test for probe polarization.

INSTRUMENT MAINTENANCE

The only maintenance required is battery replacement. Two "D" size alkaline flashlight cells, such as Eveready E95 or equivalent, will provide 200 hrs. of operation. Accuracy will not be maintained if zinc-carbon "D" cells are used. Battery replacement is indicated when the redline adjustment cannot be accomplished.

Replace batteries every six months to reduce the danger of corrosion due to leaky batteries. To replace batteries, remove the screws from the rear cover. The battery holders are color coded. The positive end must go on red.



NOTES:
Resistance values in ohms. K = 1,000. Resistors are 1/2 W, 10%, unless otherwise specified.

Battery is D size, alkaline only. Eveready E-95 or equivalent.

This schematic is representative and may be slightly different from the circuit in your instrument.

YSI MODEL 33 AND 33M SCHEMATIC

RECALIBRATION

Recalibration should be done at the factory. If emergency recalibration is necessary, however, one of the procedures described below may be attempted.

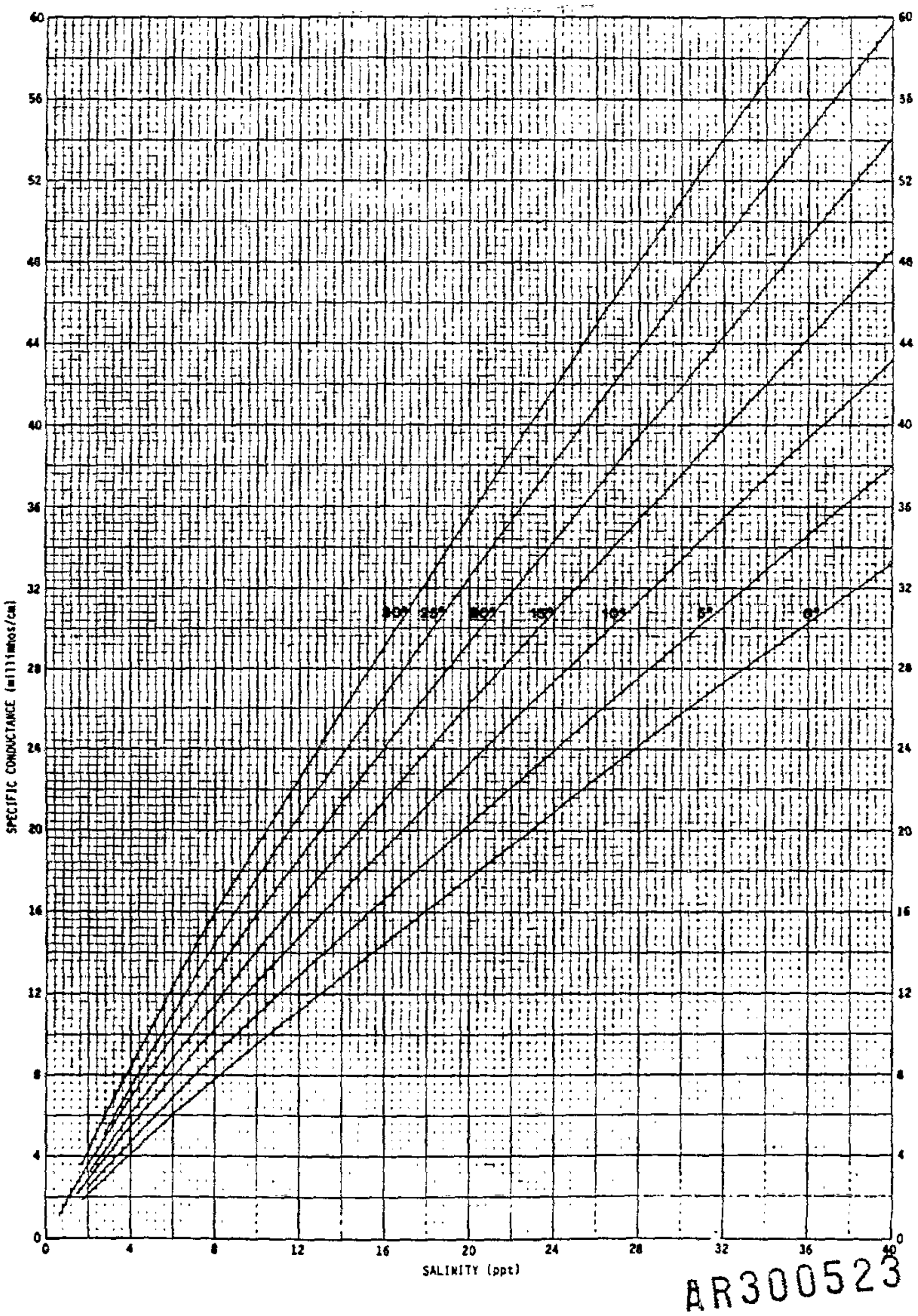
1. Use this method if the temperature knob has become loose or slipped from its normal position.

a. Read the temperature and conductivity of a sample. Determine the salinity of the solution by running a line vertically on the Calibration Graph from this conductance value until it intersects the appropriate °C line (interpolate as required for temperature between the given °C lines). From this intersection extend a line horizontally to the edge of the graph to read the salinity for this sample.

Example: 25,000 micromhos/cm (2,500 mS/m) and 20°C gives a salinity of 17 ppt.

b. Remove the temperature knob, switch to SALINITY, and turn the conrol shaft until the meter needle indicates the salinity value determined in Step a. In the example given, the value is 17.

c. Switch to TEMPERATURE and note the reading. This reading must be the same as Step in a; if it is not, begin again. Replace the knob (without turning the control shaft) with the pointer at the same temperature as the meter reading and tighten both set screws securely.

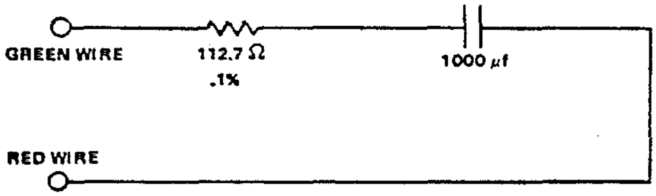


2. You may use the resistor and capacitor hookup shown in the sketch to substitute for the probe in the following recalibration procedure.

a. Set the instrument for a salinity measurement as normal.

b. Substitute a 1000 microfarad capacitor and 112.7 ohm 0.1% tolerance resistor for the probe.

Connect the resistor and capacitor between the green wire and red wire on the jack connections inside the instrument.



c. Turn the temperature dial until the meter reads redline.

d. Reinstall the temperature knob with the arrow at 25°C.

This is a temporary calibration only. Return the instrument to the factory for proper recalibration.

YSI 3300 SERIES CONDUCTIVITY/TEMPERATURE PROBES

Description

These probes are designed and constructed for rugged, accurate service in field use. The conductivity cell constant is 5.0/cm (500.0/m) ±2%. Each probe contains a precision YSI thermistor temperature sensor of ±0.1°C accuracy at 0°C and ±0.3°C at 40°C. The low capacitance cable assembly terminates in a three terminal 0.25" dia. phone plug.

The 3310 has a 10 foot cable and the 3311 a 50 foot cable. Other lengths are available on special order.

The probe has a rigid P.V.C. body, platinized pure nickel electrodes, and a rugged cable.

Cleaning and Storage

Cleaning

When the cell test indicates low readings the probable cause is dirty electrodes. Hard water deposits, oils and organic matter are the most likely contaminants.

For convenient normal cleaning soak the electrodes for 5 minutes with a locally available bathroom tile cleaning preparation such as Dow Chemical "Bathroom and Chrome Cleaner," Johnson Wax "Envy, Instant Cleaner," or Lysol Brand "Basin, Tub, Tile Cleaner."

For stronger cleaning a 5 minute soak in a solution made of 10 parts distilled water, 10 parts isopropyl alchol and 1 part HCl can be used.

Always rinse the probe thoroughly in tap water, then in distilled or deionized water after cleaning and before storage.

CAUTION: Do not touch the electrodes inside the probe. Platinum black is soft and can be scraped off.

If cleaning does not restore the probe performance, replatinizing is required.

Storage

It is best to store conductivity cells in deionized water. Cells stored in water require less frequent platinization. Any cell that has been stored dry should be soaked in deionized water for 24 hours before use.

Replatinization

1. Clean the probe.

2. Place the cell in a 50 ml (approximate) jar or beaker and add enough YSI 3140 Platinizing Solution to cover the electrodes. Do not cover the top of the probe.

3. Plug the probe into the Model 33 or 33M, switch to the X100 scale to platinize the electrodes. Move the probe slightly to obtain the highest meter reading and continue platinizing for the approximate time shown below:

Meter Reading		Time in
micromhos/cm	mS/m	minutes
30,000	3,000	5
25,000	2,500	6
20,000	2,000	8
15,000	1,500	11
10,000	1,000	16

4. After the elapsed time, remove the probe and rinse in tap water, then in distilled or deionized water.

5. Return the solution to its container. 2 oz. [illegible] solution should be sufficient for 50 treatments.

Probe Use and Precautions

1. Obstructions near the probe can disturb readings. At least two inches of clearance must be allowed from non-metallic underwater objects. Metallic objects such as piers or weights should be kept at least 6 inches from the probe.

2. Weights are attached to the cable of the YSI 3310 and 3311 Probes. The YSI 3327 Weights are supplied in pairs with a total weight of 4 ounces per pair. Should it become necessary to add more weight to overcome water currents, we suggest limiting the total weight to two pounds (8 pairs). For weights in excess of two pounds use an independent suspension cable. In either case, weights must be kept at least 6 inches away from the probe.

3. Gentle agitation by raising and lowering the probe several times during a measurement insures flow of specimen solution through the probe and improves the time response of the temperature sensor.

Conductivity and Salinity Corrections for Long Cables

The additional length of wire in long cables adds capacitance and resistance which will effect readings. The recommended way to correct for these influences is by use of YSI Conductivity Calibrator Solutions (see below), which will permit an estimate of correcti[illegible] factors. If these solutions are not available, [illegible] following tables can be used for the correction o[illegible] errors caused by cable resistance and capacitance on special length versions of the 3310, 3311, S-17933 and S-16120 probes.

INSTRUCTION SHEET
YSI 3160-3165
CONDUCTIVITY CALIBRATOR SOLUTIONS

Secondary standard solutions for the calibration of conductivity cells together with conductance meters. Not for use as a food or drug. Do not take internally. Contains: Reagent Water; 0.0002% Iodine (at the time of manufacture) as an anti-microbial, and sufficient ACS Reagent Grade Potassium Chloride to attain the target conductivity.

CATALOG NUMBER	CONDUCTIVITY AT 25.00°C	NET CONTENTS
YSI 3160	1,000 ± 5 μmhos/cm	1 US Gallon
YSI 3161	1,000 ± 5 μmhos/cm	1 US Quart
YSI 3162	10,000 ± 25 μmhos/cm	1 US Gallon
YSI 3163	10,000 ± 25 μmhos/cm	1 US Quart
YSI 3164	100,000 ± 250 μmhos/cm	1 US Gallon
YSI 3165	100,000 ± 250 μmhos/cm	1 US Quart

UNITS OF MEASURE

Resistance = ohms = Ω Conductance = siemens = S = mho

1 US Gallon = 3.785ℓ 1 US Quart = 0.9462ℓ

Conductance = 1/Resistance = Ω^{-1} (sometimes written ℧)

1 S/m=0.01 mhos/cm=10,000 μmhos/cm 1,000,000 μmhos=1,000 mmhos=1 mhos

Solution Conductivity = (Conductance) x (Cell Constant) = 1/Resistivity

DIRECTIONS FOR USE

Temperature has a large effect on conductivity! Calibration should be performed as near as practical to 25.00°C, preferably with a water bath to control temperature. If room temperature is stable and between 20°C and 30°C, the calibrator may be thermally equilibrated with the room, and then the temperature may be measured at the moment of calibration to ± 0.01C° or as accurately and precisely as possible. Electrically "compensated" readings may be taken on instruments so equipped, though this is likely to be less accurate because the temperature coefficient of the compensator may not match that of the solution, and because the circuitry of the compensator introduces additional sources of electrical error. If the compensator is adjustable, set it to 1.9%/C° for YSI 3160-3163, and to 1.8%/C° for YSI 3164-3165. To minimize compensator errors, calibrate as near as possible to 25.00°C.

Yellow Springs Instrument Co., Inc.
Yellow Springs, Ohio 45387 USA • Phone 513 767-7241 • Telex 205437

DIP CELLS: Select a glass or plastic container several inches taller than the working part of the cell and at least two inches greater in diameter. Clean and dry this container, then fill it to a depth at least two inches greater than the height of the working part of the cell. Rinse the cell by pouring a little calibrator solution into and over the cell. Connect the cell to the conductance meter and immerse the cell in the calibrator solution. For approximately two minutes, stir the solution intermittently with the cell and move the cell up and down to force liquid through the cell. Take care to purge the cell of bubbles. Position the cell approximately in the center of the calibrator solution, and at least one inch from any wall or from the surface of the solution. Record the temperature reading and record (or adjust) the conductance meter reading.

FLOW CELL: Purge the cell by passing ten to twenty times its own volume of Conductivity Calibrator Solution through it. (The volume of any connecting tubing or fittings must be considered part of the cell volume for this calculation.) When the cell temperature is stable, record the temperature of the cell and record or adjust the conductance meter reading. Micro cells may give high readings if the solution is completely stagnant--maintain some flow of solution through the cell during calibration, preferably the same rate of flow as would be used to measure an unknown solution.

FILL CELLS: Fill and empty the cell at least three times with the Conductivity Calibrator Solution. When the cell temperature is stable (allow at least two minutes), record the cell temperature and record or adjust the conductance meter reading.

When calibration is complete, rinse and store the cell in distilled water, or a dilute solution of HCl or KCl. The Conductivity Calibrator Solution is now contaminated to some extent and must not be returned to the original container.

CALCULATIONS: If the calibration was performed at 25.00°C or is ostensibly corrected to 25.00°C, the meter reading for calibrator solution should have been the nominal 25.00°C value of 1,000, 10,000 or 100,000 μmhos/cm. Adjustable meters can be trimmed to agree exactly with the nominal value of the calibrator solution. If the meter is not adjustable, or is to be used with several different probes, calculate a cell constant or a correction factor as follows:

$$\text{Cell Constant} = \frac{\text{Actual Calibrator Solution Conductivity}}{\text{Conductance Meter Reading}}$$

Conductivity readings on unknown solutions with this cell and meter may then be taken according to:

$$\text{Solution Conductivity} = (\text{Conductance Meter Reading}) \times (\text{Cell Constant})$$

For meters which presume a cell constant (not necessarily a round number) and give a reading in conductivity, it is more practical to calculate a correction factor:

$$\text{Correction Factor} = F = \frac{\text{Actual Calibrator Solution Conductivity}}{\text{Conductance Meter Reading}}$$

Unknown solution readings are then corrected by

$$\text{Correct Conductivity} = F \times (\text{Meter Reading})$$

Note that meter calibration is a factor in all these readings—unless the meters are accurately calibrated, different "cell constants" or correction factors will be obtained from the same cell and solution with different meters, or even on different ranges of the same meter. For independent calibration of conductance meters, use the YSI 3166 Conductance and Resistance Calibrator Set. If the meter or meters are not independently calibrated, the cell constant or correction factor calculated above will apply only to the very cell, meter, range and mode (for meters which read both in ohms and mhos) used in calibration. Calibrate each cell in each range and each mode for best results.

When calibrating at other than 25.00°C, without temperature compensation, use the Calibrator Solution Conductivity at the temperature of calibration (not the 25.00°C value) in the equations above. Refer to the section on Temperature Effects, which follows.

Apart from errors due to conductance meter calibration, cell constants may vary slightly with conductivity and with cell history. Calibration should therefore be undertaken with a Calibrator Solution as near as possible to that of the unknown solutions to be measured. For unknowns of very low conductivity, use the 1,000 µmhos/cm Calibrator Solutions, because lower calibrator values are less stable and less well documented. Recalibrate at six-month intervals, or following any visible change in cell condition. Cell fouling, cleaning or replatinization may have a substantial effect on cell constants, as will any mechanical bending or displacement of the electrodes.

TEMPERATURE EFFECTS

Over the range 20°C to 30°C, conductivity of the Calibrator Solutions may be calculated from the following equation:

$$\text{Conductivity} = (\text{Conductivity at } 25.00^\circ\text{C}) \times (A + BT + CT^2)$$

where T = temperature in degrees Celsius, IPTS 68. Use these coefficients:

SOLUTION	25.00° CONDUCTIVITY	A	B	C
YSI 3160 and 3161	1,000 µmhos/cm	0.5407	0.0173	0.000043
YSI 3162 and 3163	10,000 µmhos/cm	0.5538	0.0168	0.000042
YSI 3164 and 3165	100,000 µmhos/cm	0.5825	0.0157	0.000040

Nominal values are tabulated below by whole degrees. Interpolate linearly.

TEMPERATURE	YSI 3160 and 3161	YSI 3162 and 3163	YSI 3164 and 3165
20°C	904 μmhos/cm	9,066 μmhos/cm	91,260 μmhos/cm
21	923	9,251	92,980
22	942	9,437	94,730
23	961	9,624	96,480
24	981	9,812	98,230
25	1,000	10,000	100,000
26	1,020	10,190	101,770
27	1,039	10,380	103,560
28	1,059	10,571	105,350
29	1,079	10,763	107,140
30	1,098	10,956	108,950

The following tolerances apply, whichever method is used to find conductivity:

TEMPERATURE RANGE	YSI 3160-3161	YSI 3162-3165
24.5 to 25.5°C	± 0.30%	± 0.25%
22.5 to 27.5°C	± 0.35%	± 0.30%
19.5 to 30.5°C	± 0.40%	± 0.35%

NUMERICAL EXAMPLE

It is desired to measure the conductivity of groundwater which is expected to be in the range 3,000 to 8,000 μmhos/cm at 25°C. YSI 3162 is selected as an appropriate calibrator because it is 10,000 μmhos/cm at 25.00°C. About 900 ml of YSI 3162 Calibrator Solution is poured into a clean and dry 1,000 ml Erlenmeyer flask. The flask is equilibrated to room temperature. A dip cell is connected to a conductance meter. The cell is rinsed with a small quantity of Calibrator Solution which is then discarded. The cell is immersed in the Calibrator Solution. After two minutes of stirring, the solution temperature is measured with a 0.1°C thermometer and found to be 22.1°C. From the equation, the conductivity of the Calibrator Solution is then calculated:

$$\begin{aligned}\text{Conductivity} &= (10{,}000)\,[0.5538 + (0.0168)(22.1) + (0.000042)(22.1)^2] \\ &= 9{,}456\ \mu\text{mhos/cm}\end{aligned}$$

The tolerance of the Calibrator Solution at this temperature is ± 0.35%. The conductance meter reading is 9,200 mhos. Therefore, the cell constant is calculated to be:

$$\text{Cell Constant} = (9{,}456\ \mu\text{mhos/cm}) / (9{,}200\ \mu\text{mhos}) = 1.028 \pm 0.0036/\text{cm}$$

When a groundwater specimen gives a meter reading of 4,000 μmhos, the actual conductivity is

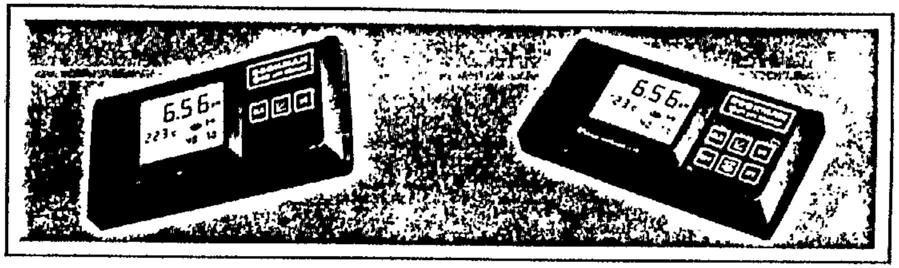
$$\text{Solution Conductivity} = (4{,}000\ \mu\text{mhos})(1.028/\text{cm}) = 4{,}112 \pm 14\ \mu\text{mhos/cm}$$

CALIBRATION, OPERATION AND MAINTENANCE INSTRUCTIONS

BECKMAN I 20 AND I 21 pH METER

BECKMAN

Φ™ 20 and Φ™ 21 pH METERS



SECTION FIVE INSTRUMENT OPERATION

This section includes: Paragraph 5.1, an introduction to the use of your instrument; Paragraph 5.2, an explanation of Ready and its meaning in operation of the instrument; and Paragraph 5.3, which lists options in pH measurement. All are illustrated with drawings that show the control keys and the symbols that appear in Display. Paragraph 5.3.4 also provides a decision path, which is a guide to the selection of pH measurement options that are appropriate to your application. Then Paragraph 5.4 describes Auto Read and Paragraph 5.5 explains restandardization.

For the most part, the first five paragraphs concern pH measurements. The instrument is also used for millivolt measurements and temperature measurements; these topics are discussed in Paragraphs 5.6 and 5.7, respectively.

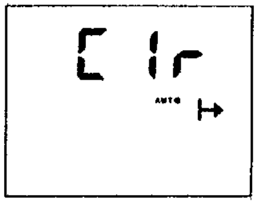
5.1 pH MEASUREMENTS: A SIMPLE AND COMMON PROCEDURE

The following standardization procedure is the easiest method for operating the instrument in the pH Mode. The required accessories and equipment are: a combination pH electrode; a Keeper Cable; one or two buffers (must be pH 1.68, pH 4, pH 7, pH 10, or pH 12.45); and several beakers.

In the example that follows, pH 4 buffer is used first and pH 10 buffer is used second. In practice, any two of the five acceptable buffers can be used in any order. Three of the buffers, which are listed in Paragraph 11.2, are color-coded for easy identification by the operator — red for pH 4, green for pH 7, and blue for pH 10.*

As an introduction to the instrument, follow the steps outlined below.

CLR Depress the CLEAR Key to clear the instrument. Display will look like this.



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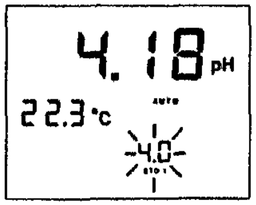
*These two buffers — pH 4 and pH 10 — are selected for illustration only. The best results are obtained when the pH values of the two buffers are close together and, if possible, bracket anticipated sample pH values.

Rinse the electrode with distilled water or pH 4 buffer and immerse in pH 4 buffer. (This symbol does not appear on the instrument. It indicates rinsing.)

Depress the STANDARD Key. The instrument recognizes this entry as the first standard. Display will look much like this, with Temperature Display indicating the measured temperature,* 22.3°C. *The actual pH reading, which changes as the electrode stabilizes, varies depending upon analytical conditions and upon the electrode used.* Both the STD 1



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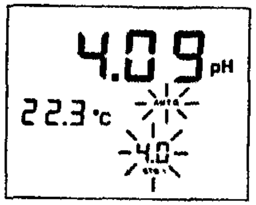
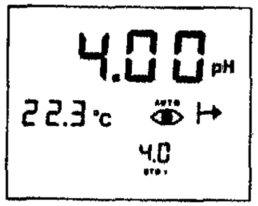
*For a discussion of temperature compensation options, refer to Paragraph 5.3.1.

Symbol and STD 1 Value flash. For details regarding behavior of the Standard(s) Display, review Paragraph 3.1.4.

Shortly, the AUTO Symbol will begin flashing, indicating that the electrode is approaching stabilization. *Std 1 Symbol and Value continue flashing.*

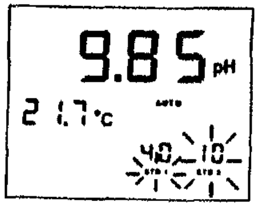


When input from the electrode is stable, Auto Read will lock, the instrument will automatically standardize on the pH value of 4.00 pH buffer at the measured temperature, 22.3°C, and the STD 1 Symbol will appear in Display along with 4.0, the approximate value of the pH 4.00 buffer. *Note that with this particular buffer the pH value at 22.3°C is the same as it is at 25°C — the usual temperature specified in describing buffer characteristics.*

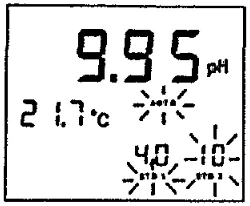


Now rinse the electrode with distilled water or pH 10 buffer, blot, and immerse in pH 10 buffer.

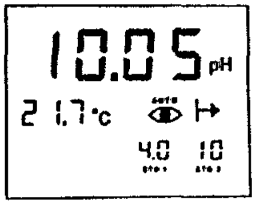
Depress the STANDARD Key again. The instrument recognizes this entry as the second standard. Display will look much like this, with Temperature Display indicating the measured temperature, 21.7°C. *Once again, the value shown may be different. And once again, it will change as the electrode stabilizes.* The STD 1 Value is on and the STD 1 Symbol flashes; the STD 2 Symbol and Value both flash. For details, refer to Paragraph 3.1.4.



The AUTO Symbol will again flash after a short time. *This flashing indicates that the Auto Read Function of the instrument has detected that the electrode is nearing stabilization.* STD 1 and STD 2 Symbols and Values behave as in the preceding stage.



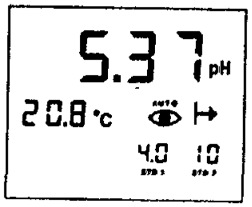
When input from the electrode is stable, Auto Read will lock, the instrument will standardize on 10.05 pH, the pH value of 10.01 pH buffer at the measured temperature, 21.7°C, and the STD 2 Symbol will be on, along with 10, the approximate value of the second buffer. The STD 1 Symbol and STD 1 Value also remain on. *When both STD Symbols and STD Values are on, as in this example, the instrument has completed two-point standardization on the indicated standard buffers.*



The instrument is now ready to make a pH measurement. Select a handy solution as the sample, rinse the electrode with distilled water or the selected sample, blot, and immerse in the sample.

pH

Depress the pH Key. Display will again activate. As the electrode approaches stability, the AUTO Symbol flashes, then Auto Read locks. Temperature Display indicates the measured temperature.



This sequence is repeated for all sample measurements. That is, depress the pH Key, wait for Auto Read to lock, and note the pH value.

Review what Display shows: Sample pH is 5.37, assuming that temperature is 20.8°C, the measured temperature. The instrument is in two-standard operation, using pH 4 and pH 10 buffers as the standards. Auto Read is employed and the instrument is in Ready, waiting for another sample or a new entry.

A great deal more has happened than would first appear. Since there was an Automatic Temperature Compensator (ATC) probe plugged in, the instrument accepted the temperatures sensed by the probe. Temperatures for STD 1, STD 2, and sample were 22.3°C, 21.7°C, and 20.8°C, respectively. Accordingly, these three values appeared successively in Temperature Display at the appropriate times, and in each case the pH value, whether of standard or sample, was corrected for temperature.

The Auto-Find™ Standardization System,* a special function of the instrument, provides for recognition of pH 1.68, pH 4.00, pH 7.00, pH 10.01, or pH 12.45 buffer. After the first buffer is measured, the instrument decides the correct buffer value. In this example, when input from the electrode is sufficiently

---

*Refer to Paragraph 4.5 for a complete description of the Auto-Find Standardization System.

stable to allow Auto Read to lock, the instrument places itself in Ready and standardizes the first point to the correct pH value of 4.00 buffer *at 22.3°C*. If the temperature were other than 22.3°C, Auto-Find would have used an appropriately adjusted value for pH 4.00 buffer.

When the electrode is standardized in the second buffer — pH 10 — the same sequence of events takes place, with the instrument standardizing to the correct pH value of pH 10.01 buffer at 21.7°C. But when Auto Read locks, the instrument automatically compensates for the unique slope — or response — of the electrode *without* disturbing the first standardization on pH 4 buffer.

And finally, during sample measurement, the instrument reads pH 5.37, the pH value of the sample at 20.8°C, the temperature measured by the ATC probe. *Note that in the absence of the probe, the instrument would, in each case, standardize at the ambient temperature of the instrument—as measured by an internal sensor.*

5.2 READY: DISPLAY FUNCTIONS

READY Symbol ⇥ Before proceeding further, one instrument function needs to be explained because it reflects the state of the instrument. When the READY Symbol is displayed, the instrument is in an idle state, ready to accept your command; it is not reading the value from the electrode. For brevity, the instrument is said to be in Ready.

⬚ When the READY Symbol is off, the instrument is in the Read Mode, in which Display is actively monitoring electrode response. Note that the instrument is in either the Ready State or in the Read Mode, as indicated by the presence or absence of the READY Symbol.

5.3 pH MEASUREMENT OPTIONS

Now that you have made some measurements and understand the meaning of Ready, look at options available for your specific application. This paragraph lists and discusses the following options:

1. Automatic Temperature Compensation by an ATC probe or operation at ambient temperature of the instrument, as detected by a thermistor.
2. Single-point standardization, two-point standardization, or no standardization.
3. Auto Read or operator determination of electrode stability (pHI 21 pH Meter only).

5.3.1 TEMPERATURE COMPENSATION OPTIONS

The simple procedure in Paragraph 5.1 assumed two-point standardization with a pH 4 buffer and a pH 10 buffer and operation at the indicated temperatures. The instrument then uses each temperature value in standardization and sample measurements to make temperature compensations.

It is possible to standardize the instrument using two standards at different temperatures and make sample measurements at other temperatures. The various temperature values are retained by the instrument and used for temperature compensation. Examples of the options that are given below should be reviewed to determine which is best for your application.

1. *Ambient Temperature of the Instrument*
   The instrument adopts ambient temperature when there is no Automatic Temperature Compensator (ATC) probe connected to the instrument. Display shows the value of the ambient temperature when this assumption is being made. When ambient temperature is used, temperature compensation is based upon the temperature of the instrument's surroundings, as sensed by an internal thermistor. *Note that for best results this option for temperature compensation should be used only if ambient is close to the temperature of the standard(s) and samples.*
2. *Temperature Compensation by an ATC Probe*
   An Automatic Temperature Compensator (ATC) probe can be used to provide the temperature input automatically. (Refer to Paragraph 11.1, Accessories, for the part number.) When the probe is connected (plugged in), Temperature Display indicates the temperature sensed by the probe.

The following table lists the pH value as a function of temperature for acceptable buffers. This information is provided 1) as a convenient reference, and 2) to emphasize the importance of temperature in pH measurement.

BUFFER VALUES AT VARIOUS TEMPERATURES
(for Beckman Buffers*)

TEMP °C	BUFFERS pH 1.68	pH 4.00	pH 7.00	pH 10.01	pH 12.45
0	1.67	4.00	7.12	10.32	13.42
5	1.67	4.00	7.09	10.25	13.21
10	1.67	4.00	7.06	10.18	13.00
15	1.67	4.00	7.04	10.12	12.81
20	1.68	4.00	7.02	10.06	12.63
25	1.68	4.00	7.00	10.01	12.45
30	1.68	4.01	6.99	9.97	12.29
35	1.69	4.02	6.98	9.93	12.13
40	1.69	4.03	6.97	9.89	12.04
45	1.70	4.04	6.97	9.86	11.84
50	1.71	4.06	6.97	9.83	11.70

*The Auto-Find Standardization System operates properly only if the buffers used have the same temperature/pH characteristics as the corresponding Beckman Buffers.

5.3.2 STANDARDIZATION OPTIONS

Standardization options include the following: standardization with one standard solution, standardization with two standard solutions; or — for rough approximations — operation without using any standard at all. The latter assumes that the electrode has 99% of ideal slope. These options are discussed immediately following and should be reviewed to determine which is best for your application.

1. *One-Point Standardization*

   One-point standardization corrects for electrode offset, but not for slope. One-point standardization is useful when samples are close in pH value to the buffer standard pH value and therefore corrected slope is not critical. For example, with samples in the pH range between pH 3.5 and pH 4.5, the instrument should be standardized using a pH 4 buffer.

   When standardizing at only one point, select a buffer that is close to the expected pH value of the sample. The instrument assumes 99% of temperature-compensated ideal slope, corrects for electrode offset, and indicates one-point standardization on the display.

2. *Two-Point Standardization*

   Two-point standardization corrects for offset and computes slope. It should be used when greater accuracy is required and when the sample pH values vary over a wide range and the electrode slope is critical. For example, with samples that vary over a pH range of 3 to 8, an initial standardization could be performed using a pH 4 buffer and the slope adjustment (second standard point) could be performed using a pH 7 buffer to complete the standardization. Remember that Paragraph 5.1 is a detailed example of two-point standardization.

   To go from one-standard to two-standard operation, the two-point standardization must be done consecutively without any sample readings between the first and second standardization. Two-standard operation computes slope and corrects offset. Paragraph 5.1 provides an example using Auto-Find on pH 10 and pH 4 buffers to demonstrate the steps involved to obtain a two-point standardization.

3. *No Standardization*

   When no standardization is employed, the instrument computes pH by assuming 99% of ideal slope and no offset. The instrument returns to this condition when cleared. If standardization is not used, depress the pH Key to take a reading. This is the least accurate method since electrodes seldom have both ideal slope and no offset. It should be used only for rough approximations.

5.3.3 AUTO READ ON/OFF OPTION (pHI 21 pH Meter *only*)

On the pHI 21 pH Meter, Auto Read is another primary option that needs to be considered. It applies to standardization as well as to sample measurements. Auto Read has been used during all the previous examples.

AUTO

The Auto Read Function may be disabled at any time by a single depression of the AUTO READ Key. The instrument will then continue to read data until it is placed in another mode, until it is turned off or cleared, or until time runs out (Paragraph 2.2). Auto Read locks if 10 successive readings (10 seconds) are within a ±1.0 millivolt range.

5.3.4 pH MEASUREMENT OPTIONS: A DECISION PATH

DECISION 1

IS MEASUREMENT PRECISION BETTER THAN 0.2 pH REQUIRED?

If the answer is YES, choose two-point standardization, or one-point standardization if all sample pH values are within ±0.5 pH of the standard buffer pH value. Both are described in Paragraph 5.3.2. Then go on to Decision 2.

OPERATING INSTRUCTIONS

BECKMAN I 10 AND I 11 pH METERS

AND

I 12 pH/SE METER

BECKMAN

Φ™10 pH Meter
Φ™11 pH Meter
Φ™12 pH/ISE Meter

pH MEASUREMENT: DETAILED INSTRUCTIONS

METHODS: The pHI 10, 11, and 12 can measure pH from 0 to 15.99. They will perform one- or two-point standardization automatically, using any buffer listed below, at any temperature between −5°C and 100°C.

STANDARD pH BUFFERS RECOGNIZED BY THE pHI 10, 11, AND 12:

1.68, 4.00, 7.00, 10.01, 12.45.

TWO-POINT STANDARDIZATION METHOD:

Two-point standardization, the preferred and more accurate method of pH measurement, should be used when pH accuracy of beyond ± 0.1 pH is required. Use buffers as close to the sample pH as possible; one above, and one below. (For example, if sample pH is *about 8.5, use 7.00 and 10.01 pH buffers*).

ONE-POINT STANDARDIZATION METHOD:

One-point standardization, a somewhat faster procedure, is recommended only if (a), *accuracy of ± 0.1 pH unit is acceptable, and (b), sample pH is within 1.5 pH of that of the* buffer used for standardization.

pH MEASUREMENT PROCEDURE:

1. Connect electrode(s) to appropriate input(s):
    a. If a *combination electrode* is used, connect it to the input marked "pH".
    b. If an *electrode pair* is used, connect the indicating electrode *to the input marked* "pH" and the reference electrode to the input marked "REF".
    c. For better accuracy, or when measuring and/or standardizing at a temperature of other than 25°C, connect a Beckman 598115 Automatic Temperature Compensator probe to input marked "ATC".

---

2. *Press* [⏻] *to turn on instrument, then press* [c] to clear. Display will show [Clr, AUTO].
3. Rinse electrode(s) (and ATC if used) with deionized water. Blot excess.
4. Immerse electrode(s) (and ATC if used) in first standard. Stir briefly with electrodes to *remove bubbles from electrode surfaces. Press* [pH]. *Displayed pH value will have a* resolution of 0.01. If 0.1 resolution is desired, press [⅒].
5. Press [STD]. When [◉] stops flashing, display will show [pH value locked, ◉, ▶ STD 1].
6. Rinse electrode(s) (and ATC probe if used) with deionized water. Blot excess. Proceed to appropriate step, according to desired type of standardization:
    a. If ONE-POINT standardization is to be used, instrument is ready for sample measurement; proceed to Step 9.
    b. *If TWO-POINT standardization is desired, proceed to* Step 7.
7. Immerse electrode(s) (and ATC if used) in second standard. Stir briefly with electrodes to remove bubbles from electrode surfaces. Press [STD]. When [◉] stops flashing, display will show [pH value locked, ◉, ▶ STD 1, ▶ STD 2].
8. Rinse electrode(s), (and ATC probe if used) with deionized water. Blot excess.
9. Immerse electrode(s) (and ATC if used) in sample. Stir briefly with electrodes. Press [pH]. *When* [◉] *stops flashing, display will show* [pH value locked, ◉]. Measurement is now complete. Repeat Steps 8 and 9, above, for additional samples.
10. If *continuous* pH monitoring is desired, press [AUTO] to turn off Auto Read function.

BATTERY REPLACEMENT

Your Φ10, 11, or 12 is powered by two 3.6 volt lithium batteries. Expected battery life is over 1,000 hours of continuous operation. Replacement batteries can be obtained by ordering Part No. 945754 from your local Beckman office. (In U.S. call 1-800-742-2345).

Acceptable replacement batteries are also available on a world-wide basis:

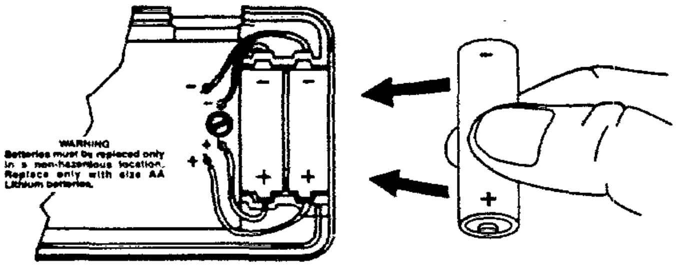
Mfr	Part No.
Electrochem Industries	3B940-TC
Power Conversion Inc.	TO6-41
Saft Advanced Battery Div.	LS6
Tadiran	TL-2100 AA/S

Local suppliers may be found in your telephone directory.

> *Note that these batteries are 3.6 volt lithium cells. Do not attempt to replace them with 1.5 volt* alkaline or carbon-zinc cells.

If instrument display indicates low battery voltage ⟨🔋⟩ or if display is blank when instrument is turned on, batteries should be replaced:

1. Remove 2 Phillips screws and bottom cover from instrument.
2. Lift out old batteries.
3. *Note (+) and (–) markings in battery compartment.*
4. Check (+) and (–) markings on batteries and insert as shown:

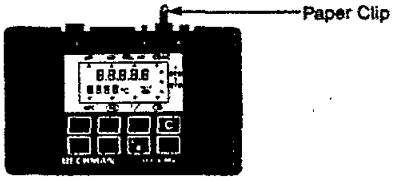


5. Replace back cover and screws.

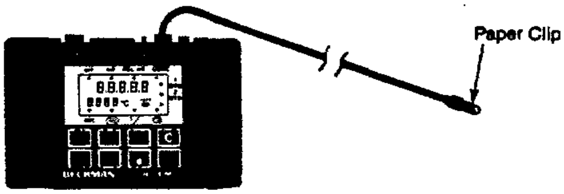
> IMPORTANT: A "BREAK-IN" PERIOD OF UP TO 30 MINUTES IS REQUIRED WHEN SOME NEW LITHIUM BATTERIES ARE FIRST PLACED INTO SERVICE. DURING THIS PERIOD, THE LOW BATTERY SYMBOL AND SOME "GHOSTING" MAY APPEAR ON *THE DISPLAY. IF SO, LEAVE INSTRUMENT ON FOR 20–30 MINUTES AND THEN* PRESS $\boxed{\text{C}}$. THE LOW BATTERY SYMBOL AND "GHOSTING" SHOULD DISAPPEAR.

TROUBLESHOOTING PROCEDURE

1. Disconnect electrode cable(s) from instrument. Press $\boxed{⏻}$ to turn on instrument, then press $\boxed{\text{C}}$ to clear. Display should show [Clr, AUTO]. If not, replace batteries per BATTERY REPLACEMENT, above. If instrument is still inoperative, call Service Hot Line: 1-800-662-6217.
2. *Insert one end of a paper clip into the small hole in the center of the "pH" input connector.* Hold the other end of the clip to the inside barrel of the same connector as shown.



3. Press $\boxed{\text{pH}}$, then $\boxed{\text{STD}}$. The display should lock at pH 7.00, indicating a one-point standardization.
   - a. If instrument passes test, go to Step 4.
   - b. If instrument fails test, call Service Hot Line: 1-800-662-6217.
4. Reconnect pH electrode cable to "pH" input connector. Short the input connector of the cable.



Press $\boxed{\text{pH}}$ and then $\boxed{\text{STD}}$. Display should lock at pH 7.00. Press $\boxed{\text{pH}}$, then remove paper clip. Reading should drift.
   - a. If instrument passes test, go to Step 5.
   - b. If instrument fails test, call Beckman Electrochemistry Applications:

     1-800-854-8067 Outside California
     714-871-4848 Within California

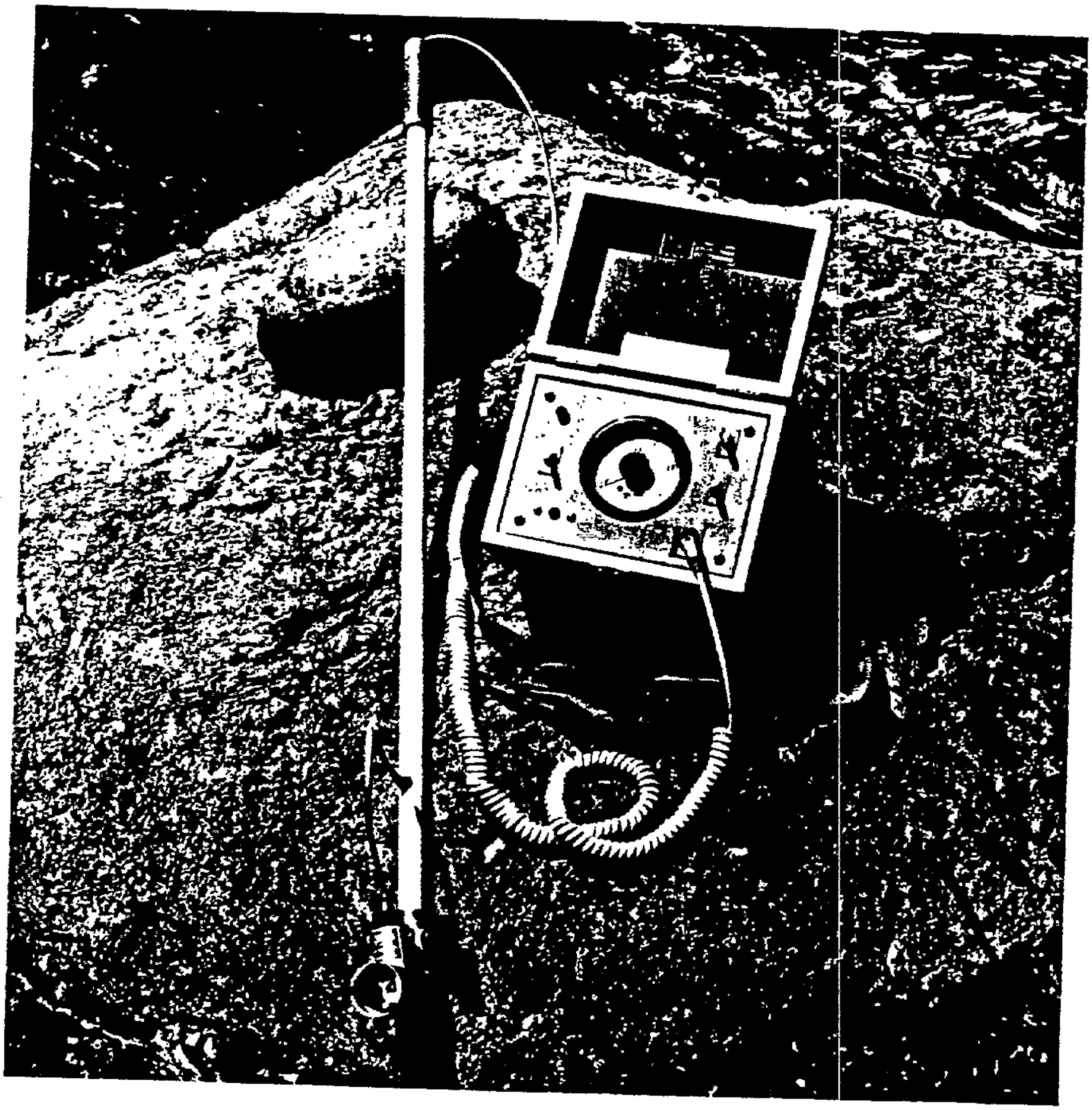
5. Reconnect pH electrode(s). Immerse electrode(s) in pH 4 buffer and perform one-point standardization. Then immerse electrode(s) in pH 10 buffer and take pH reading. At 25°C, the reading should be between 9.7 and 10.1 pH.
   - a. If the test is passed, the pH meter, cable, and electrode(s) are functioning properly.
   - b. If test is failed, the pH electrode(s) must be rejuvenated or replaced. The electrode rejuvenation procedure is given in the electrode instruction sheet. After rejuvenation, retest per Step 5, above.

OPERATION, CALIBRATION AND MAINTENANCE INSTRUCTIONS

HP-302 OPEN STREAM VELOCITY PROBE

HP-302

OPEN STREAM VELOCITY PROBE



FEATURES:

LOW COST • ACCURATE • FIELD PROVEN • UNCOMPLICATED
DIRECT READING • PORTABLE • RUGGED • TIME SAVING

APPLICATIONS:

SEWERS • INFLOW AND INFILTRATION STUDIES • INDUSTRIAL WASTE
POLLUTION CONTROL • STREAM GAUGING • IRRIGATION MONITORING

MODEL HP-302
OPEN STREAM VELOCITY PROBE

INTRODUCTION:

An accepted and field proven instrument, the HP-302 System consists of the PT-301 Hand-Held Probe and the FI-15P Portable Indicator. It is designed for use in pollution control, hydrological, irrigation, sewer surveys, and similar activities requiring the measurement of open stream water velocities. Readings are instantaneous and accurate with no counters, timers, or lengthy test periods required. No calculations or complicated electronic adjustments are necessary. All readings are direct and may be made by unscientific personnel. Two ranges give improved accuracy. The Indicator is light-weight, rugged, and splash-proof, with a shoulder strap for easy carrying and one-hand operation. Optional probe extensions enable measurement of sewer flows from street level.

DESCRIPTION:

The PT-301 Probe consists of a low inertia molded turbine mounted in a protective shroud at the end of an aluminum handle. The turbine, when immersed in a flowing stream, rotates at a speed in direct linear relationship to the fluid velocity. A small magnet sealed within the turbine hub produces an electrical pulse in an adjacent induction transducer for each rotation. The frequency of these pulses is thus also a direct measure of the fluid velocity. The FI-15P Indicator is actually a portable frequency meter or frequency to DC converter. It amplifies and conditions the pulses to drive a meter indicator in a direct relationship to their frequency. The indicator scale is calibrated to read in the desired units of fluid velocity. The electronic system is stable, accurate, and all solid state. It is drift-free and requires no operational adjustments. All power is obtained from a set of 8 standard "C" size flashlight batteries. The current drain is less than that of a normal flashlight bulb. The Indicator is housed in a durable wood-grained Formica case with shoulder strap and removable cover.

RANGES:

Each instrument has two ranges with 0-5 and 0-10 ft. per second as standard. Optional ranges are 0-7.5 and 0-15 ft. per second or the equivalent in meters, knots, or other units of measure. The threshold of operation is approximately 0.25 ft. per second for all ranges. Accuracy is ± 2% of any range.

APPLICATIONS:

Measurement of industrial or municipal sewers, pollution entering streams or rivers, stream velocity for flood control, flow patterns in filter beds, or even flow out of large pipes or ducts. The unique adjustable head of the probe allows insertion into pipe ends or for vertical velocity measurements. It also enables determination of direction of current in complex stream flows. The small size of the turbine makes possible the measurement of streams as shallow as 1½ inches. These are features not possible with most other meters.

U. S. PAT. NO. 4,030,359
OTHERS PENDING

MEAD INSTRUMENTS CORPORATION

ONE DEY LANE – RIVERDALE, NEW JERSEY 07457
201-835-5988

6/77

MEAD INSTRUMENTS MODEL HP-302 OPEN STREAM VELOCITY PROBE

OPERATING INSTRUCTIONS:

1. Plug probe with its extension cable into the connector jack marked PROBE.
2. Turn ON power switch.
3. Check battery condition by momentarily placing the BAT-TEST switch in the TEST position. Meter should indicate in green area of dial for proper battery voltage and accurate measurements. If indication is below green area, the batteries are weak and should be replaced.
4. Check operation of system by blowing on the turbine.
5. Adjust angle of probe head or shroud so that the center-line of the turbine will be parallel with the flow stream to be measured.
6. Immerse head completely in the stream, facing flow. Note position of range switch when reading scale.
7. Conserve batteries by turning off power between tests.
8. Wash off probe in clean fresh water after each test period, particularly after measurements in sewage, salt water or other corrosives. After cleaning blow on turbine to test its freedom.

MAINTENANCE:

As with any electronic instrument, it is essential that the indicator and all electrical connections be kept clean and dry. Particular care must be taken around salt water. If it is necessary to work in the rain, place a plastic bag over the indicator. Show the instrument the respect it deserves and it will give many years of service, abuse it and you will pay the price.

MAINTENANCE NOTES:

- Periodically check the turbine shaft with a small screw driver. It should be "snug" and not loose. (It is highly recommended that a spare turbine and shaft be kept on hand in case of loss. They are interchangeable without recalibration.)

- If turbine fails to spin smoothly when blown, unscrew shaft and clean parts thoroughly under running water. Carefully replace parts. If turbine fouls with entrained matter during a test, rotate the head 180° and often the stream will flush out the material.

- When disconnecting cables, always pull on the body of the connector, NEVER pull on the cable. A slight clockwise twist of the connector will help.
- CAUTION: When transporting this instrument in a vehicle always place indicator on the seat or other cushion. Do not place on floor or in trunk, road shock can be detrimental to the meter.

MEAD INSTRUMENTS MODEL HP-302 OPEN STREAM VELOCITY PROBE

BATTERY REPLACEMENT:

Regardless of use, the batteries should be replaced annually or removed completely during periods of long storage. The acid from over age batteries can be destructive to the equipment.

Standard "C" size carbon-zinc flashlight batteries are normally supplied with the instrument. Battery life is a function of usage and therefore not predictable, but usually several months of service can be expected. Replacement of the standard batteries with the more expensive alkaline type, Eveready No. E93 or equal, will extend the life at least four times.

REPLACEMENT:

1. Remove detachable indicator cover.
2. Turn indicator over on a flat surface.
3. Indicator assembly is retained in its case by a single screw at the center of the underside. Remove the screw and carefully lift the case off of the indicator assembly.
4. Replace all eight "C" size flashlight batteries in the holders. OBSERVE PROPER DIRECTION AND POLARITY.
5. Carefully replace case and retaining screw.

CALIBRATION:

The calibration has been carefully set at the factory and will remain stable, if unmolested, for extended periods of time. The calibration control is beneath the hole plug at the lower left side of the indicator panel. This should never be touched or readjusted without the proper measurement standards. Re-checking will require an audio oscillator whose frequency is monitored by a digital frequency meter. The output of the oscillator is substituted for the probe and applied at the PROBE jack. The test frequency will be the full scale range of the indicator multiplied by the calibration factor as shown on the Data Sheet. The voltage of the applied test signal should not exceed 2 volts RMS. The threshold if the indicator is normally less than 10 Mv. If the proper test instrumentation is not available, the indicator should be returned to the factory for recalibration.

CALIBRATION AND MAINTENANCE INSTRUCTIONS

CENTURY 128 ORGANIC VAPOR AND ANALYZER

METHOD NO. M-3B

1.0 INTRODUCTION

The OVA is capable of responding to nearly all organic compounds. For precise analyses it will be necessary to calibrate the instrument with the specific compound of interest. This is especially true for materials containing elements other than carbon and hydrogen.

The instrument is factory calibrated to a methane in air standard. However, it can be easily and rapidly calibrated to a variety of organic compounds. A GAS SELECT control is incorporated on the instrument panel which is used to set the electronic gain to a particular organic compound.

Internal electronic adjustments are provided to calibrate and align the electronic circuits. There are four (4) such adjustments all located on the electronics board. One adjustment potentiometer, R-38, is used to set the power supply voltage and is a one-time factory adjustment. The remaining three adjustments, R-31, R-32, and R-33 are used for setting the electronic amplifier gain for each of the three (3) calibrate ranges. Access to the adjustments is accomplished by removing the instrument from its case.

2.0 REFERENCE

Foxboro Analytical, Instruction and Service Manual - Model OVA128, Arkansas City, Kansas.

3.0 CALIBRATION

3.1 Electronic Adjustments

Primary calibration of this instrument is accomplished at the factory using methane in air sample gases.

3.2 Gain Adjustment

a) Place instrument in normal operation with CALIBRATE switch set to X10 and GAS SELECT control set to 300.

b) Use the CALIBRATE ADJUST (zero) knob and adjust the meter reading to zero.

c) Introduce a methane sample of a known concentration (near 100 ppm) and adjust trimpot R-32 on circuit board so that meter reads equivalent to the known sample.

d) This sets the instrument gain for methane with the panel mounted gain adjustment (GAS SELECT) set at a reference number of 300.

e) Turn off H_2 SUPPLY VALVE to put out flame.

3.3 Bias Adjustment

a) Leave CALIBRATE switch on X10 position and use CALIBRATE ADJUST (zero) knob to adjust meter reading to 4 ppm.

b) Place CALIBRATE switch in X1 position and, using trimpot R-31 on circuit board, adjust meter reading to 4 ppm.

c) Move CALIBRATE switch to X10 position again. Use CALIBRATE ADJUST (zero) knob to adjust meter to a reading of 40 ppm.

d) Move CALIBRATE switch to X100 position and use trimpot R-33 on circuit board to adjust meter reading to 40 ppm.

e) Move CALIBRATE switch to X10 position and use CALIBRATE ADJUST (zero) knob to adjust meter reading to zero.

f) Unit is now balanced from range to range, calibrated to methane, and ready to be placed in normal service.

4.0 MAINTENANCE

4.1 Fuel Refilling

a) The instrument should be completely shut down during hydrogen tank refilling operations. The refilling should be done in a ventilated area. There should be no potential igniters or flame in the area.

b) If you are making the first filling of the instrument or if the filling hose has been allowed to fill with air, the filling hose should be purged with N_2 or H_2 prior to filling the instrument tank. This purging is not required for subsequent fillings.

c) The filling hose assembly should be left attached to the hydrogen supply tank when possible. Ensure that the FILL/BLEED valve on the instrument end of the hose is in the OFF position. Connect the hose to the refill connection on the Side Pack Assembly.

d) Open the hydrogen supply bottle valve slightly. Open the REFILL VALVE and the H_2 TANK VALVE on the instrument panel and place the FILL/BLEED valve on the filling hose assembly in the FILL position. The pressure in the instrument tank will now be indicated on the H_2 TANK PRESSURE indicator.

e. After the instrument fuel tank is filled, shut off the REFILL VALVE on the panel, the FILL/BLEED valve on the filling hose assembly and the hydrogen supply bottle valve.

f) The hydrogen trapped in the hose should now be bled off to atmospheric pressure. CAUTION should be used in this operation as described in Step (g) below, since the hose will contain a significant amount of hydrogen at high pressure.

g) The hose is bled by turning the FILL/BLEED valve on the filling hose assembly to the BLEED position. After the hose is bled down to atmospheric pressure, the FILL/BLEED valve should be turned to the FILL position to allow the hydrogen trapped in the connection fittings to go into the hose assembly. Then, again, turn the FILL/BLEED valve to the BLEED position and exhaust the trapped hydrogen. Then turn the FILL/BLEED valve to OFF to keep the hydrogen at one atmosphere in the hose so that at the time of the next filling there will be no air trapped in the filling line.

h) Close the H_2 TANK VALVE.

i) With the H_2 TANK VALVE and the H_2 SUPPLY VALVE closed, a small amount of H_2 at high pressure will be present in the regulators and plumbing. As a leak check, observe the H_2 TANK PRESSURE indicator while the remainder of the system is shut down and ensure that the prssure indication does not go down rapidly, indicating a significant leak. If it does decrease rapidly (greater than 350 PSIG/hr.), there is a significant leak in the H2 supply system.

4.2 Battery Recharging

a) Plug charger BNC connector into mating connector on battery cover and insert AC plug into 115 VAC wall outlet. Never charge in a hazardous area or enviroment.

b) Move the battery charger switch to the ON position. The light above the switch button should illuminate.

c) Battery charge condition is indicated by the meter on the front panel of the charger; meter will deflect to the right when charging. When fully charged, the pointer will be in line with "charged" marker above the scale.

d) Approximately one hour of charging time is required for each hour of operation. However, an overnight charge is recommended. The charger can be left on indefinitely without damaging the batteries. When finished, move the battery charger switch to OFF and disconnect from the Side Pack Assembly.

The following are special instructions relative to batteries which have been allowed to completely discharge.

It has been established that the above battery recharging procedures may not be sufficient when the operator of the instrument has inadvertently left the INSTR switch ON for a peiod of time without recharging and allowed the battery to completely discharge.

When this happens and the above-procedures fail to recharge the battery, the following should be accomplished:

1) Remove the battery from the instrument case.

2) Connect to any variable DC power supply.

3) Apply 40 volts at 1/2 amp maximum.

4) Observe the meter on the power supply frequently and as soon as the battery begins to draw current, reduce the voltage on the power suply at a slow rate until the meter reads approximately 15 volts. NOTE: The time required to reach the 15 volt reading will depend on degree of discharge.

5) Repeat steps a), b), c), and d) above to continue charging.

4.3 Filters

a) Primary Filter

This filter is located behind the sample inlet connector (Fitting Assembly) on the Side Pack Assembly and is removed for cleaning by using a thin wall socket to unscrew the Fitting Assembly. The filter cup, "O" ring and loading spring will then come out. The porous stainless filter cup can then be cleaned by blowing out or washing in a solvent. If a solvent is used, care should be taken to ensure that all solvent is removed by blowing out or heating the filter. Reassemble in reverse order ensuring that the "O" ring seal on the Fitting Assembly is intact.

b) Particle Filters

A particle filter is located in each pickup fixture. One of these filters must be in the sample line whenever the instrument is in use. The Models OVA-88 and OVA-138 use a disposable cellulose filter which should be changed as often as required. The Models OVA-96, OVA-108, OVA-188, and OVA-128 use a porous metal filter which can be replaced or cleaned using the cleaning procedure above.

c) Mixer/Burner Assembly Filter

Another porous metal particle filter is incorporated in the Mixer/Burner Assembly which screws into the Preamp Assembly. This filter is used as the sample mixer and inlet flame arrestor in the chamber. This filter should not become contaminated under normal conditions but can be cleaned or the assembly replaced if necessary.

Access to this filter for output surface cleaning is gained by simply unscrewing the exhaust port from the Preamp Assembly without removing the instrument from the case. The OVA-108, OVA-128, and OVA-138 instruments require removal of the safety cover prior to unscrewing the exhaust port. The Filter Assembly can now be seen on the side of the chamber (Preamp Assembly) and can be scraped or cleaned with a small wire brush.

If filter replacement is required, install a new or factory rebuilt Mixer/Burner Assembly. In several OVA models, this requires removal of the Preamp Assembly.

d) Exhaust Flame Arrestor

A porous metal flame arrestor is located in the exhaust port of the detector chamber (Preamp Assembly). See Side Pack Assembly drawing. It acts as a particle filter on the chamber output and restricts foreign matter from entering the chamber. This filter may be cleaned, if required, by removing the exhaust port from the Preamp Assembly. The exhaust port is removed from the bottom of the case without case removal. Note that the filter is captive to the exhaust port on the Models OVA-108, OVA-128, and OVA-138. Clean the filter with a solvent or detergent but ensure that it is dry and any solvent completely baked out at 120°F before reinstalling.

e) Pickup Fixtures

The pickup fixtures should be periodically cleaned with an air hose and/or detergent water to eliminate foreign particle matter. If a solvent is used, the fixture should be subsequently cleaned with detergent and baked out at 120°F to eliminate any residual hydrocarbons from the solvent.

Method M - 3B
Rev. 0
May, 1984

REQUEST FOR APPROVAL OF PHOENIX
METHOD NO. M - 3B
CENTURY 128 OVA CALIBRATION AND MAINTENANCE

Don C. Wolski, Requester	Date
Ann G. Federoff, Mgr., Q.A.	Date
Terrence A. Shannon, Vice President Phoenix Safety Associates, Ltd.	Date
Anthony A. Fuscaldo, Ph.D., President Phoenix Safety Associates, Ltd.	Date

CALIBRATION, OPERATION AND MAINTENANCE

HNU MODEL PI 101

PORTABLE PHOTOIONIZATION ANALYZER

INSTRUCTION MANUAL

S/N 701400

MODEL PI 101

Portable Photoionization Analyzer

hnu

INSTRUCTION MANUAL

TRACE GAS ANALYZER

HNU MODEL PI 101

HNU Systems, Inc.
160 Charlemont St.
Newton, MA 02161

December 1985

The PI 101 is a non-destructive analyzer; work in a hood if toxic or hazardous gases are used. In the interest of greater international acceptance the HNU Model PI 101-100 Photoionizer has been certified by Sira Safety Services Ltd. to conform to Article 501-3 of the National Electrical Code to be non-incendiary for Class 1 Division 2, Groups A, B, C and D locations Effective July 25, 1984.

SIRA Approval #APL/33/84

SECTION 1

GENERAL INFORMATION

1.1 INTRODUCTION

This manual describes the operation, maintenance and parts list for the Trace Gas Analyzer, Model PI 101, HNU Systems Inc.

1.2 EQUIPMENT DESCRIPTION

The Trace Gas Analyzer (see Figure 1-1), is a portable instrument used to detect, measure, and provide a direct reading of the concentration of a variety of trace gases in many industrial or plant atmospheres. The analyzer employs the principle of photoionization. This process involves the absorption of ultra-violet light (a photon) by a gas molecule leading to ionization:

$$RH + hv \longrightarrow RH^{+} + e^{-}$$

in which

RH = Trace gas
hv = Photon with an energy level equal to or greater than the ionization potential of RH.

The sensor consists of a sealed ultraviolet (UV) light source that emits photons with an energy level high enough to ionize many trace species, particularly organics, but not high enough to ionize the major components of air, O_2, N_2, CO, CO_2 or H_2O.

A chamber exposed to the light source contains a pair of electrodes, one a bias electrode and the second a collector electrode. When a positive potential is applied to the bias electode a field is created in the chamber. Ions formed by the absorption of photons are driven to the collector electrode. The current produced is then measured and the corresponding concentration displayed on a meter directly in parts per million (ppm).

To minimize absorption or decomposition of sample gases, a rapid flow of sample gas is maintained thru the ion chamber, which is small, made of inert material and located at the sampling point.

The analyzer consists of a probe, a readout assembly, and a battery charger. The probe contains the sensing and amplifying circuitry; the readout assembly contains the meter, controls, power supply and rechargeable battery. The analyzer will operate from the battery for more than 10 hours or continuously when connected to the battery charger.

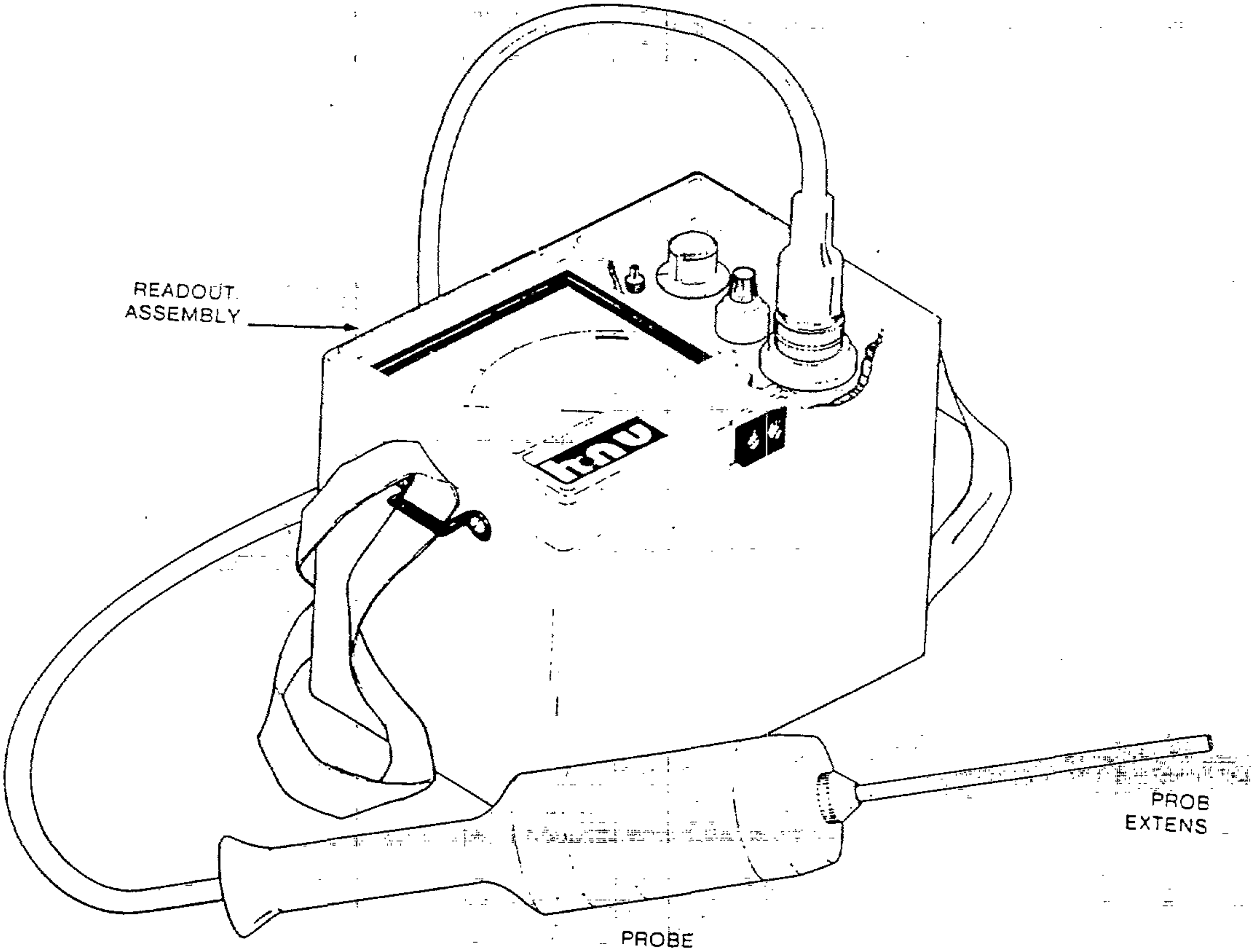


FIGURE 1-1
TRACE GAS ANALYZER
OPERATING CONDITION

The PI 101 is designed for use with interchangeable probes with lamps of different energies. The analyzer is ready for use simply by connecting the probe to the readout assembly, setting the proper SPAN pot value, and then zeroing the unit. Specific data is given in the calibration memo accompanying each probe.

The standard probe uses a 10.2 eV lamp. Two optional probes use 9.5 and 11.7 eV lamps. Lamps of different eV ratings, ion chamber and amplifiers are not interchangeable between probes.

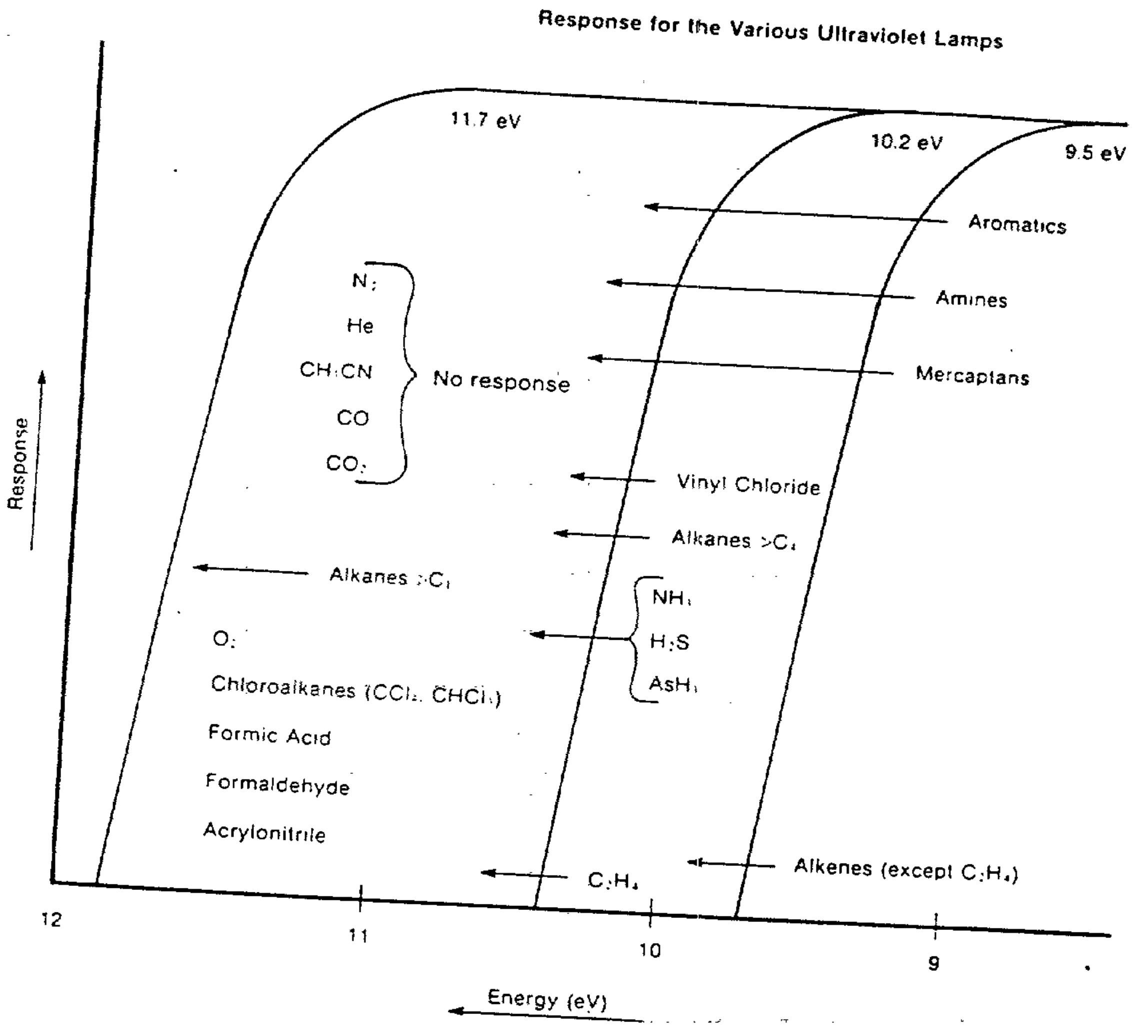
Many applications make use of the principle that some compounds respond to the more energetic lamps and not to others. Figure 1-2 shows the responses for the analyzer with each of the three lamps. Literature explaining several such applications is available from HNU Systems Inc.

An optional audible alarm is available giving an 85 decibel signal when a set concentration is exceeded. The alarm setting is variable and can be set from 0 to 100% of full scale of the meter reading. Power for the alarm is provided by the battery and does not significantly affect the rated use time of the analyzer. The alarm is non-latching and is set by a screw adjustment, preventing inadvertent changes.

When in the stored condition, the probe is contained in the instrument cover (see Figure 1-3) which attaches to the readout assembly to form a single unit (see Figure 1-4).

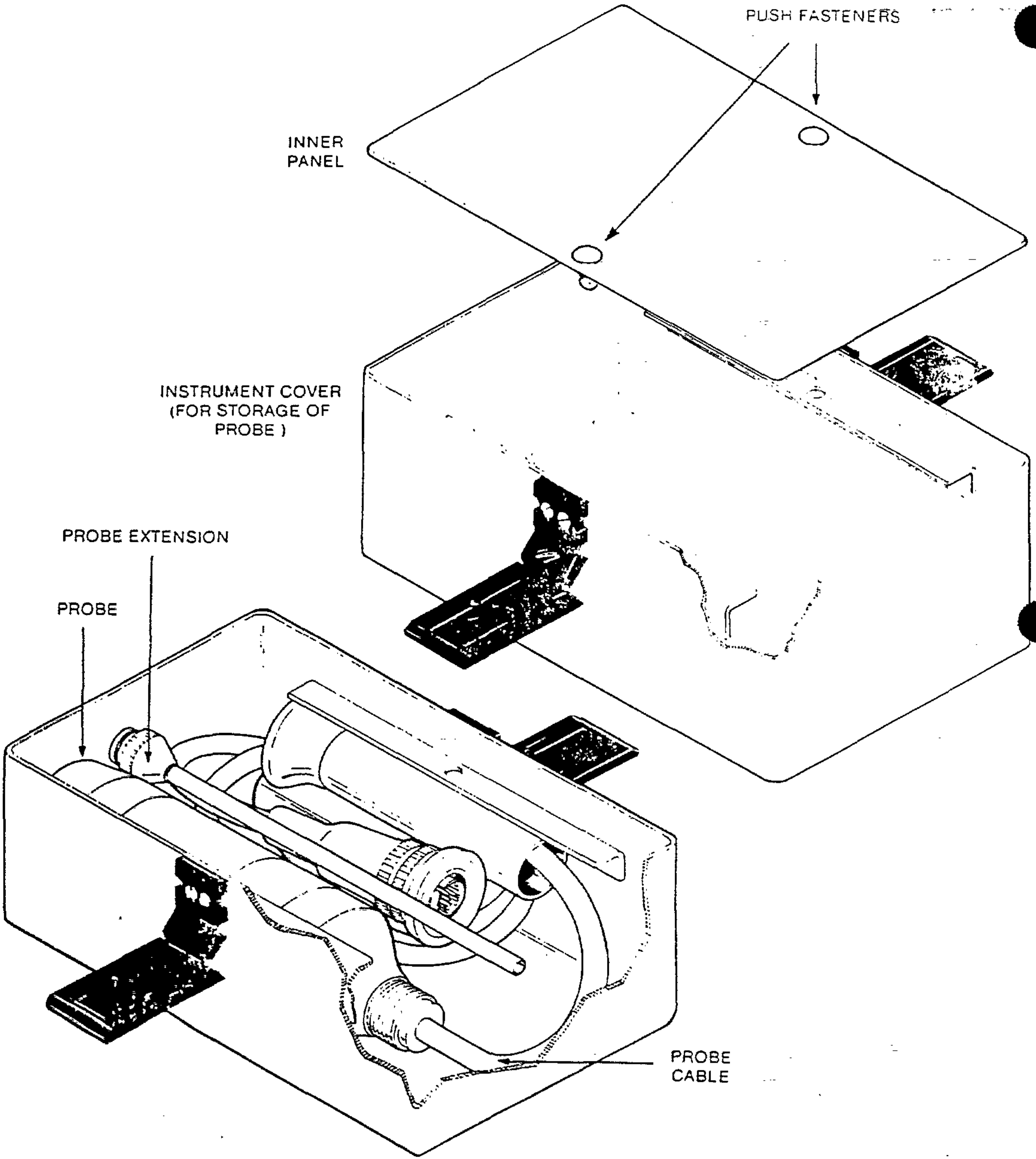
An optional recorder is available that can be directly attached to the readout assembly. It uses impact paper with a 2" wide chart and a speed of 2"/hour. The recorder is powered by the instrument battery and provides hard copy of the data. The analyzer will operate for approximately 4 hours with the recorder attached. Mounting information and illustration is given in Section 8.

Specification data on the analyzer is given in Table 1-1. Physical characteristics of the equipment are given in Table 1-2.



Response for the Various Ultraviolet Lamps

FIGURE 1-2
RESPONSE TO VARIOUS COMPOUNDS
FOR EACH ULTRAVIOLET LAMP



Repeated storage of probe in this manner is not recommended due to cable wear. Instrument cover may also be used for sto battery charger.

FIGURE 1-3
PROBE STORAGE
INSTRUMENT COVER

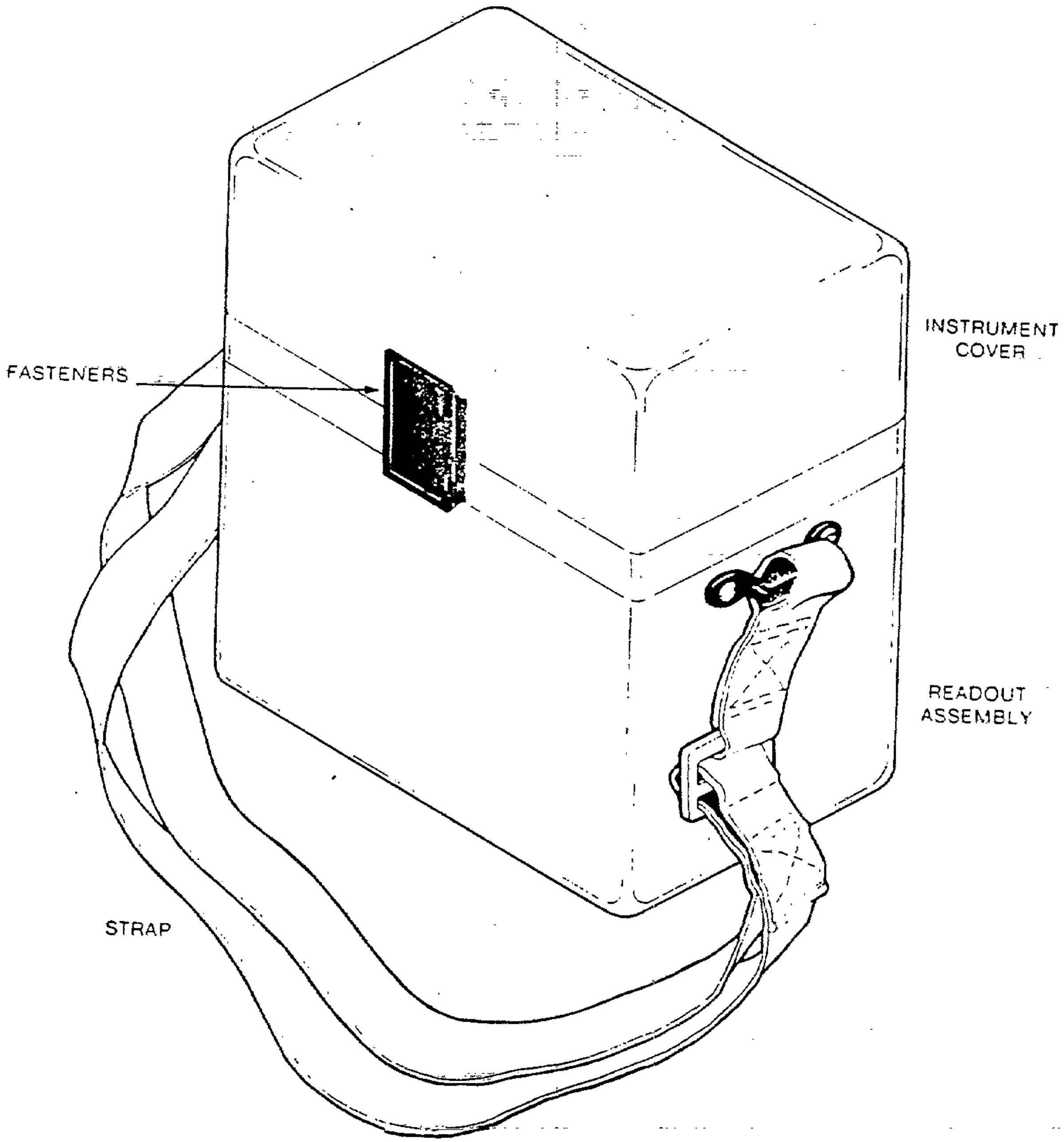


FIGURE 1-4
TRACE GAS ANALYZER
STORED CONDITION

TABLE 1-1

SPECIFICATION DATA

a. DESIGN FEATURES

Range settings	0 to 20, 200, 2000 ppm (other ranges available on request)
Lamp rating	10.2 eV standard, 9.5 or 11.7 eV optional
Audible alarm, low or high limit (optional)	85 db at 3'

b. CHARACTERISTICS (see NOTE)

Detection Range *	0.1 to 2000 ppm (parts per million by volume)
Minimum Detection Level *	0.1 ppm
Maximum Sensitivity *	0 to 20 ppm FSD at SPAN = 9.8 (full scale deflection) 0 to 2 ppm FSD at SPAN = 0.0
Repeatability *	+/- 1% of FSD
Linear Range *	0.1 to 400 ppm
Useful Range *	0.1 to 2000 ppm
Response Time	Less than 5 seconds to 90% of FSD
Ambient Humidity	up to 90% RH (relative humidity)
Operating Temperature, Ambient	-10 to 40 degrees C.
Operating Time on Battery, continuous use, without HNU recorder	Approximately 10 hours; at lower temperatures time is reduced due to effect of cold temperature on battery.
with HNU recorder (optional)	Approximately one half of normal time

TABLE 1-1 cont.

Recharge time from full discharge	Full recharge - 12 to 14 hours
Recharge current	Max 0.4 amps at 15 V DC
Battery Charger Power	120 V AC, single phase, 50-60 cy 1.5 Amps

NOTE: * When equipped with 10.2 eV Probe with SPAN set at 9 and measuring benzene. Values will vary for other compounds and conditions.

TABLE 1-2

EQUIPMENT SIZE & WEIGHT

Quantity	Name	Overall dimensions cm (inches)	Weight, kg (lbs.)	Volume, cm3 (cu. ft.)
1	Trace Gas Analyzer (stored condition)	21W x 13D x 24H (8 1/4 x 5 3/16 x 9 1/2)	3.8 (8.2)	6552 (0.23)
	Probe Assembly	6.3 Diam x 28.5L (2 1/2 x 11 1/4)	0.55 (1.2)	564 (0.02)
	Readout Assembly	21W x 13D x 16.5H (8 1/4 x 5 3/16 x 6 1/2)	3.2 (7.0)	4504 (0.16)
1	Battery Charger with cord	10W x 12.7D x 9L (4 x 5 x 3 1/2)	0.4 (0.9)	1143 (0.04)

SECTION 2

OPERATION

.1 INTRODUCTION/UNPACKING

Unpack the instrument carefully. The carton will contain the housing, straps, battery charger, additional probes, regulator and cylinder if ordered, spare parts, supplies and a manual. Be sure all items are removed before discarding the carton.

Attached to the instrument is a warranty card which should be filled out completely and returned to HNU Systems.

2.2 CONTROLS AND INDICATORS

The controls and indicators are located on the front panel of the readout assembly (see Figure 2-1) and are listed and described in Tables 2-1 and 2-2.

.3 OPERATING PROCEDURES

The following procedures are to be used in operating the analyzer:

a. Unclamp the cover from the main readout assembly.

b. Remove the inner lid from the cover by pulling out the two fasteners.

c. Remove the probe, handle and cable from the cover. Attach the handle to the front part of the probe.

d. Connect the probe cable plug to the 12 pin keyed socket on the readout assembly panel. Carefully match the alignment slot in the plug to the key in the connector. Screw down the probe connector until a distinct snap and lock is felt.

e. Screw the probe extension into the probe end cap. The probe may be used without the extension if desired.

f. Set the SPAN control for the probe being used (10.2, 9.5, or 11.7 eV) as specified by the initial factory calibration or by subsequent calibrations.

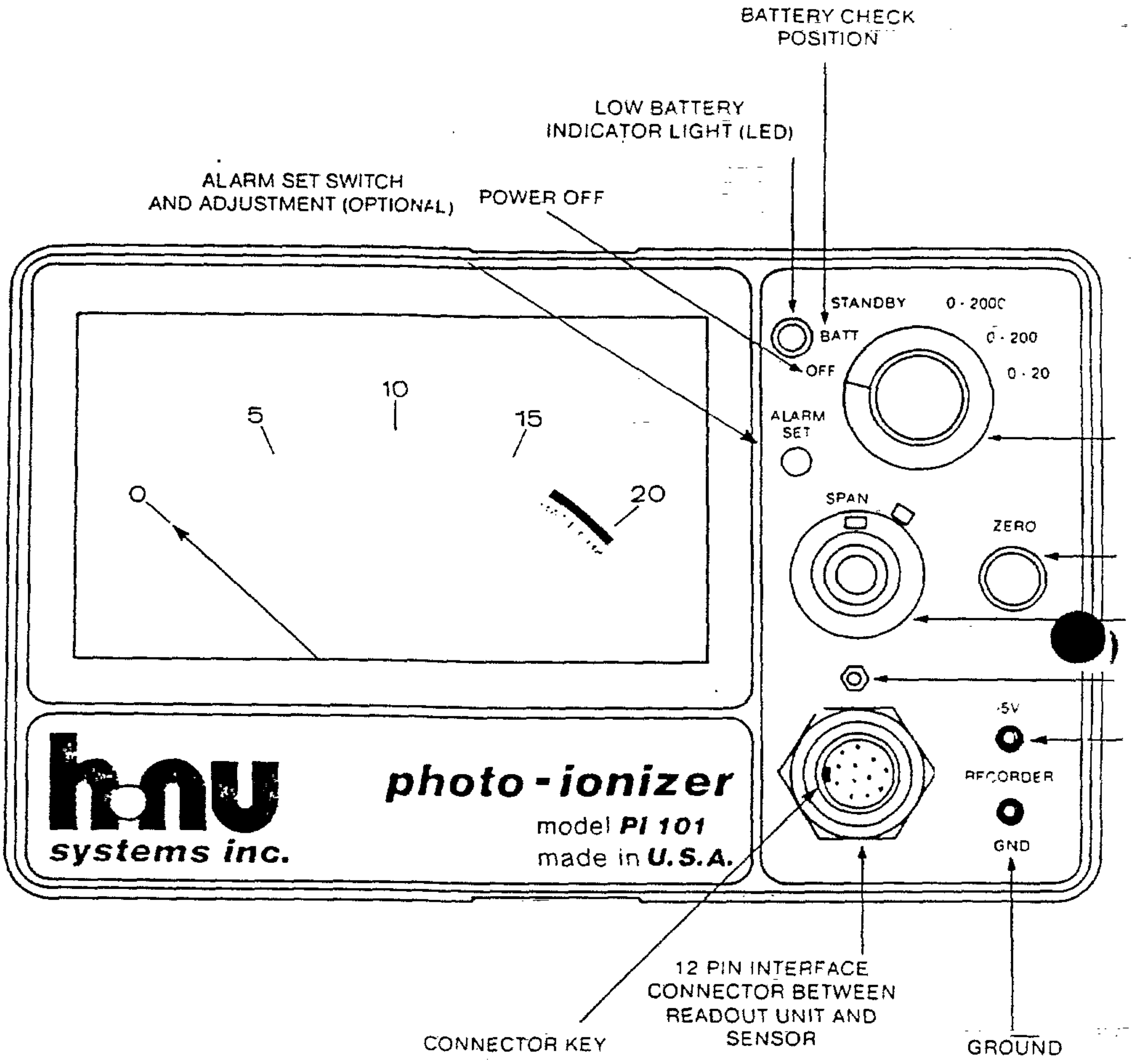


FIGURE 2-1
CONTROLS AND INDICATORS

TABLE 2-1

CONTROLS

Name	Position	Function
Function Switch	---	Controls the operation of the analyzer
	OFF	All operations OFF
	BATT (battery check)	Checks the condition of the battery. If the meter needle is in the green arc, the battery is charged. If not the battery should be recharged. Charging can be done in any position, best in OFF; see directions on charger.
	STANDBY	All electronics ON, ultraviolet (UV) light source OFF. This position conserves power and extends battery life. This position is used to set the analyzer zero position. (i.e. no UV light, no signal)
	0-2000	Sets range of meter at 0-2000 ppm.
	0-200	Sets range of meter at 0-200 ppm.
	0-20	Sets range of meter at 0-20 ppm.
ZERO	---	With the function switch in STANDBY position, this potentiometer is used to adjust the reading to zero.

NOTE: See Figure 2-1 for locations.

TABLE 2-1 cont.

SPAN	---	This vernier potentiometer is used to set the gain of the amplifier to give direct readings of the trace gas concentrations in ppm. The whole number of the setting appears in the window of the control, decimal appears on the dial. A lock secures it at a specific setting.
HI-VOLTAGE	---	This is a normally open microswitch.
	Open	Switch is open when cable not connected, disconnecting high voltage for the UV lamp from the 12 pin connector as a safety precaution.
	Closed	Switch is automatically closed when the cable is attached. This switch may also be closed manually during maintenance checks of the readout assembly without the probe cable attached.
ALARM SET (optional)	---	Potentiometer with screwdriver adjustment. Turns the audible alarm ON or OFF and sets the ppm level at which the alarm sounds. If alarm is low limit, it sounds when measured ppm falls below this value. If alarm is high limit it sounds when measured ppm exceeds this value.

NOTE: See Figure 2-1 for locations.

TABLE 2-2

INDICATORS AND DISPLAYS

Name	Function
Low Battery Indicator Light (red light) (see NOTE)	Illuminates when battery is discharged, indicates need for recharge. Do not use unit when this light is ON. Readings may be taken while battery is being recharged.
Meter (see NOTE)	Indicates concentration of measured gas.
Recorder (optional) (see Figures 2-1 And 8-3)	Provides a record of readings while analyzer operates unattended. Recorder inputs 0 to -5 V DC.

NOTE: See Figure 2-1 for locations.

g. Turn the function switch to the BATT (battery check) position. The needle on the meter will go to the green zone if the battery is fully charged. If the needle is below the green arc or if the Low Battery Indicator comes on, the battery must be recharged before the analyzer is used.

h. Set SPAN pot to the desired value based on the gas to be used.

i. Turn the function switch to the STANDBY position. Turn the zero adjustment until the meter needle is at zero.

j. Calibrate the instrument daily as described in Section 3. Calibration on the selected operating range is desirable.

k. If equipped with optional alarm, set or check the alarm setting at the level desired. Turn the function switch to the desired range, turn the zero adjustment control so the meter needle moves upscale thru the desired value. This simulates real conditions. Observe the reading when the alarm sounds. Adjust the ALARM SET, if required, with a screw driver. Turn the function switch to the STANDBY position and reset the zero position (para. h. above). If the range is to be changed, the alarm must be reset on that range.

l. To operate with optional recorder, add the recorder bracket (see Figure 8-3). Remove the plug in the analyzer case and insert power cord into the recorder. Then connect the signal leads to the appropriate jacks in the control module. The recorder is now operational.

NOTE: Ranges must be marked on the chart as the recorder prints the meter display as % of Full Scale.

m. Turn the function switch to the appropriate operating position. Start with the 0-2000 position and then switch to the more sensitive ranges. The UV light source should be on, confirmed by briefly looking into the probe to observe a purple glow from the lamp.

WARNING

Do not look at the light source closer than 6 inches with unprotected eyes. Observe only if necessary, then only briefly. Continued exposure to ultraviolet energy generated by the light source can be harmful to eyesight.

n. The analyzer is now operational.

o. Hold the probe so that the extension is at the point where the measurement is to be made. The instrument measures the concentration by drawing the gas in at the end of the extension, through the ionization chamber, and out the handle end of the probe.

WARNING

The instrument measures gases in the vicinity of the operator and a high reading when measuring toxic or explosive gases should be cause for action for operator safety.

p. Take the reading or readings as desired taking into account that air currents or drafts in the vicinity of the probe tip may cause fluctuations in readings. Change the ranges as required.

q. Check battery condition as required. If the Low Battery Indicator comes on, turn analyzer off and recharge.

CAUTION

Use only in an emergency with a low battery when on battery charge.

r. After completion of use, check battery condition as described in para. g.

s. Turn function switch to OFF position.

t. When not operating, leave analyzer in assembled condition, and connected to battery charger.

u. When transporting, disassemble probe and extension from readout assembly and return equipment to its stored condition.

v. In case of emergency, turn function switch to OFF position.

2.4 BATTERY CHARGE

Check the battery charge as described in paragraph 2-3 g during each period of operation, at least once daily. If the battery is low as indicated by the meter reading or the warning indicator, it is necessary to recharge the battery.

To charge the battery, first insert the mini phone plug of the charger into the jack, J6, on the side of the bezel adjacent to the meter. Then insert the charger plug into a 120 or 230 V AC single phase, 50-60 cycle outlet. To ensure that the charger is functioning, turn the function switch, S1, to the battery check (BATT) position. The meter should deflect full scale if the charger is working and connections properly made. For normal battery charging, leave the function switch in the OFF position.

The analyzer can be operated, however, while recharging by turning the function switch to the desired position. Such usage will extend the time required to completely recharge the battery. The battery charger is not Div. II approved.

NOTE: On all Sira approved PI 101s it is necessary to connect the probe assembly before turning on the instrument and re-charging. Without following this procedure the instrument will not show battery check.

SECTION 3

CALIBRATION

.1 INTRODUCTION

The PI 101 Analyzer is designed for trace gas analysis in ambient air and is calibrated at HNU with certified standards of benzene, vinyl chloride and isobutylene. Other optional calibrations are available (e.g., ammonia, ethylene oxide, H2S, etc.). Calibration data is given in the data sheet. If a special calibration has been done, the data is given in the Application Data Sheet, which notes the sample source, type of calibration (see Section 8, Appendix), and other pertinent information.

Good instrumentation practice calls for calibration on the species to be measured in the concentration range to be used. This procedure assures the operator that the analyzer is operating properly and will generate reliable data.

Some general points to consider when calibrating the PI 101 are that the analyzer is designed for operation at ambient conditions and therefore the gas standards used for calibration should be delivered to the analyzer at ambient temperatures and pressure and at the proper flow rates.

WARNING:

The PI 101 is a non-destructive analyzer; calibrations using toxic or hazardous gases must be done in a hood.

The frequency of calibration should be dictated by the usage of the analyzer and the toxicity of the species measured. If the analyzer has been serviced or repaired, calibration should be done to verify operation and performance. It is recommended that calibration be checked frequently at first (daily or every other day) and then regularly based on the confidence level developed.

The normal meter scaleplate is 0 to 20. If the scaleplate is different, refer to the Application Data Sheet. If there are questions, consult the HNU representative before proceeding with calibration check.

An accurate and reliable method of calibration check is to use an analyzed gas cylinder in a test setup as shown in Figure 3-1 and described below. Additional material on calibration is given in Section 8, Appendix.

3.2 ANALYZED GAS CYLINDER

a. Concentration - The calibration gas cylinder is to contain the species of interest made up in an air matrix at or near the concentration to be analyzed. If the component is unstable in air, another matrix is to be used. The final calibration mixture should be similar to the sample the PI 101 will analyze. If the expected concentration is not known then a concentration should be chosen that will cause a scale displacement of 50 to 80% on the X10 range. Calibration on X10 range will provide accurate values on the X1 range as well.

For use on the 0-2000 range, a two-standard calibration is preferred: one at 70 to 85% of the linear range and the other at 25 to 35% of the linear range. With the linear range of approximately 600 ppm for most compounds these points would lie between 420 to 510 ppm and 150 to 210 ppm, respectively.

b. Stability - The calibration gas must be stable within the cylinder during the period of use. If the calibration is required in the field, then use of a small cylinder is recommended. In addition, the choice of cylinder material in contact with the gas must be considered (steel, aluminum or teflon). If there are any questions, the operator should request stability and usage information from the gas supplier.

WARNING

Extreme care must be taken in the handling of gas cylinders. Contents are under high pressure. In some cases, the contents may be hazardous. Many gas suppliers will provide data sheets for the mixtures upon request.

c. Delivery - The cylinder containing the calibration mixture must be connected to a proper regulator.

WARNING

Never open the valve on a gas cylinder container without a regulator attached.

Leak test all tank/regulator connections as well as the main cylinder valve to prevent toxic or hazardous materials from leaking into the work area. Care must be taken that the materials of construction of the regulator will not interact with the calibration gas.

One method of sampling the calibration gas is illustrated in Figure 3-1. Connect the cylinder to one leg of the tee, a flow meter to the opposite leg, and the probe to the third leg. The flow meter does not require a valve. If there is a valve, it must be left wide open. the flowmeter is only to indicate excess flow. Adjust the flow from the regulator such that only a little excess flow is registered at the flowmeter.

This insures that the PI 101 sees the calibration gas at atmospheric pressure and ambient temperature.

d. Usage - Generally, a gas cylinder should not be used below 200-300 psi as pressure effects could cause concentration variations. The cylinder should not be used past the recommended age of the contents as indicated by the manufacturer. In case of difficulty, verify the contents and concentration of the gas cylinder.

e. Alternate means of calibration are possible. For more information, contact the HNU Service Department.

.3 PROBE

a. Identify the probe by the lamp label. If a question exists, disassemble the probe and inspect the lamp. The energy of the lamp is etched into the glass envelope.

b. Connect the probe to the readout assembly, making sure the red interlock switch is depressed by the ring on the connector.

c. Set the SPAN pot to the proper value for the probe being calibrated. Refer to the calibration memo accompanying the probe.

d. Check the Ionization Potential (IP) of the calibration gas to be used. The IP of the calibration gas must be at or below the IP of the lamp.

e. Proceed with the calibration as described in Section 3.4. Check the calibration memo for specific data. If any questions develop, call the HNU representative.

f. NOTE: The 11.7eV lamp has a special cleaning compound. Do not use water or any other cleaning compound with the 11.7 eV lamp. Do not interchange ion chambers, amplifier boards or lamps between probes. (See Section 5.2).

3.4 PROCEDURE

a. Battery check - Turn the function switch to BATT. The needle should be in the green region. If not, recharge the battery.

b. Zero set - Turn the function switch to STANDBY. In this position the lamp is OFF and no signal is generated. Set the zero point with the ZERO set control. The zero can also be set with the function switch on the X1 position and using a "Hydrocarbon-free" air. In this case "negative" readings are possible if the analyzer measures a cleaner sample when in service.

c. 0-20 or 0-200 range - For calibrating on the 0-20 or 0-200 range only one gas standard is required. Turn the function switch to the range position and note the meter reading. Adjust the SPAN control setting as required to read the ppm concentration of the standard. Recheck the zero setting (step b.). If readjustment is needed, repeat step c. This gives a two-point calibration; zero and the gas standard point. Additional calibration points can be generated by dilution of the standard with zero air if desired (see Section 8).

d. 0-2000 range - For calibrating on the 0-2000 range, use of two standards is recommended as cited in Section 3.2a. First calibrate with the higher standard using the SPAN control for setting. Then calibrate with the lower standard using the ZERO adjustment. Repeat these several times to ensure that a good calibration is obtained. The analyzer will be appoximately linear to better than 600 ppm, (see Figure 3-2). If the analyzer is subsequently to be used on the 0-20 or 0-200 range, it must be recalibrated as described in steps b. and c. above.

e. Lamp cleaning - If the span setting resulting from calibration is 0.0 or if calibration cannot be achieved, then the lamp must be cleaned (see Section 5.2).

f. Lamp replacement - If the lamp output is too low or if the lamp has failed, it must be replaced (see Section 5.3).

3.5 CALIBRATION CHECKING

Rapid calibration checking in the field can be accomplished by use of a small disposable cylinder containing isobutylene. Immediately after a calibration has been completed, a reading is taken on a special isobutylene standard. This provides a reference concentration measurement for later checking in the field. This can be done at any time with a portable cylinder containing this same special standard, using this reference reading as a check, and making adjustments to the analyzer if necessary. In effect, this is an indirect method of calibration, one maintaining the calibration to give direct readings for the original gas mixture, but using the portable isobutylene cylinder. Details are given in Section 8.2 of the Appendix.

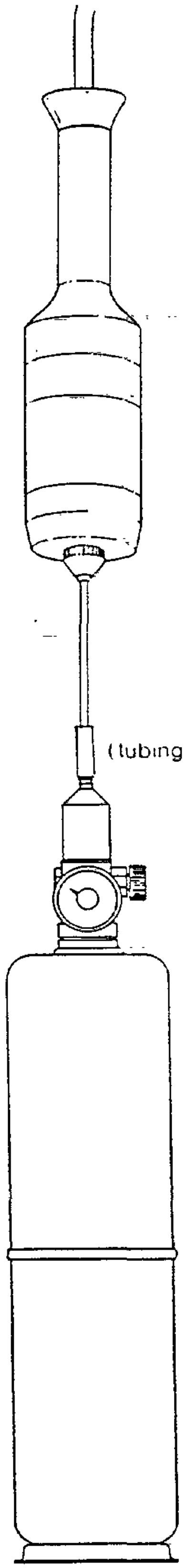
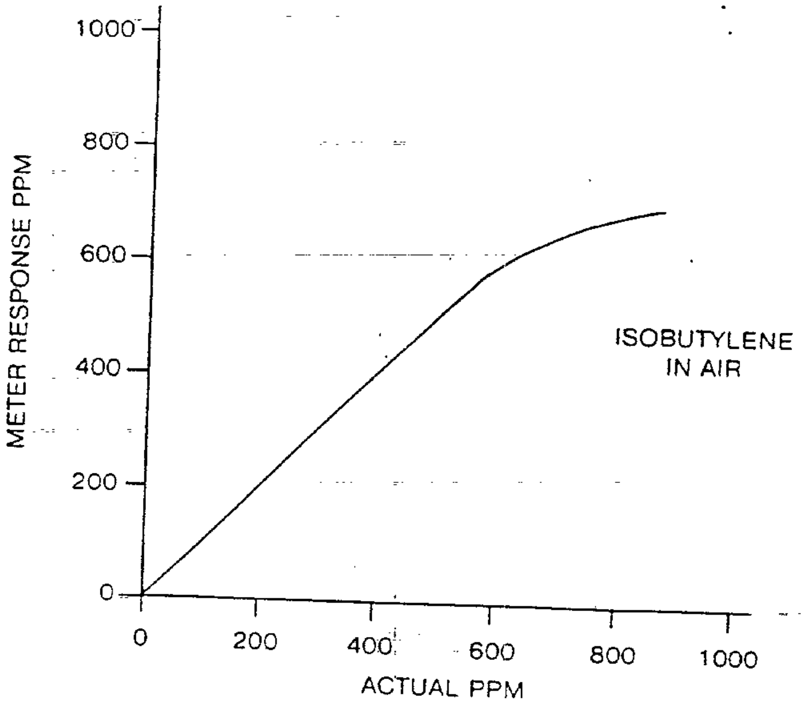


FIGURE 3-1
CALIBRATION TEST SET UP



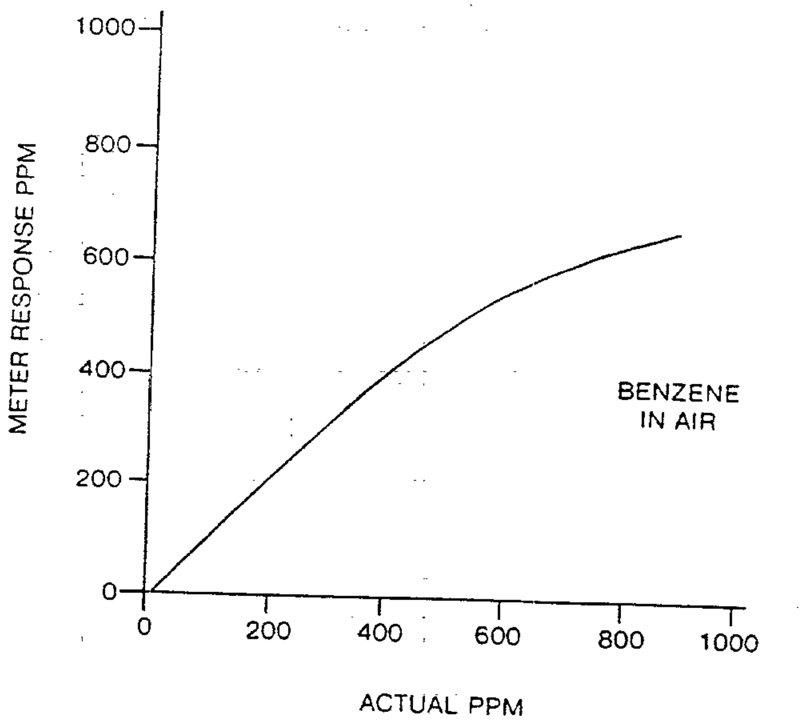


FIGURE 3-2
TYPICAL CALIBRATION CURVES (10.2 eV)

SECTION 5

MAINTENANCE

5.1 INTRODUCTION

Maintenance of the analyzer consists of cleaning the lamp and ion chamber, replacement of the lamp or other component parts or subassemblies.

WARNING: Turn the function switch on the control panel to the OFF position before any disassembly. Otherwise, high voltage of 1200 V DC will be present.

WARNING: Use great care when operating the analyzer with the readout assembly outside its case due to the presence of 1200 V DC.

WARNING: Do not look at the light source from any closer than 6 inches with unprotected eyes. Observe only briefly. Continued exposure to ultraviolet energy generated by the light source can be harmful to eyesight.

CAUTION: Do not interchange lamps of different eV ratings in a probe. Amplifier and components are selected for a specific eV lamp. A probe with the wrong lamp will not operate properly.

.2 UV LAMP AND ION CHAMBER CLEANING

During periods of operation of the analyzer, dust or other foreign matter could be drawn into the probe forming deposits on the surface of the UV lamp or in the ion chamber. This condition is indicated by meter readings that are low, erratic, unstable, non-repeatable, or drifting, or show apparent moisture sensitivity. These deposits interfere with the ionization process and cause erroneous readings. Check for this condition monthly or as required. Cleaning can be accomplished as follows:

a. Disassemble the probe and remove the lamp and ion chamber (see Section 5.5). Exercise great care in doing so to prevent inadvertent damage to these components.

b. First check the lamp window for fouling by looking at the surface at an incident angle. Any deposits, films or discoloration may interfere with the ionization process. Clean the window as follows:

1) 9.5 and 10.2 eV lamps

   a) First clean by rubbing gently with lens tissue dipped in a detergent solution.

   b) If this does not remove deposit, apply a small amount of HNU cleaning compound (PA101534) directly onto the lens of the lamp and spread evenly over surface with a non-abrasive tissue (e.g. Kim-Wipe) or a lens tissue.

   c) Wipe off compound with a new tissue.

   d) Rinse with warm water (about 80 degrees F) or damp tissue to remove all traces of grit or oils and any static charge that may have built up on the lens. Dry with new tissue.

   e) Reinstall lamp in detector and check analyzer operation.

   f) If performance is still not satisfactory replace the lamp. See Section 5.3 and Section 6.

2) 11.7 eV lamp

   a) Clean by putting a freon or chlorinated organic solvent on a tissue and rubbing gently.

   b) DO NOT CLEAN THIS LAMP WITH WATER OR ANY WATER MISCIBLE SOLVENTS (methanol or acetone). It will damage the lamp.

   c) DO NOT USE THE CLEANING COMPOUND used for the 9.5 and 10.2 eV lamps under any circumstances on the 11.7 eV lamp.

c. Then inspect the ion chamber for dust or particulate deposits. If such matter is present, the chamber can be cleaned by removing the outer Teflon ring, and the four screws holding the retaining ring. Carefully move the retaining ring aside (NOTE: this is soldered) and remove the screen. A tissue or cotton swab, dry or wetted with methanol, can be used to clean off any stubborn deposits. The assembly can also be gently swirled in methanol and dried gently at 50-60 degrees C for approximately a half hour. No liquid must be present at reassembly as this would affect the performance. Do not clean the ion chamber with the HNU cleaning compound cited above in para. b.1)b).

d. Reassemble the probe and check analyzer operation.

e. If performance is still not satisfactory replace the lamp. See Section 5.3.

LAMP REPLACEMENT

To replace the lamp, disassemble the probe, remove the old lamp, install a new one of the same eV rating and reassemble.

WARNING

Turn the function switch on the control panel to the OFF position before disassembly. Otherwise, high voltage of 1200 V DC will be present.

CAUTION

Do not exchange lamps of different eV ratings in a probe. Amplifier and components are selected for a specific eV lamp. A probe with the wrong lamp will not operate properly.

Set the SPAN pot to 9.8 for the 10.2 eV lamp. Remove the readout assembly case (see Section 5.6). Locate the gain control potentiometer, R48, on the power supply board as shown on Figure 6-1. Recalibrate the analyzer adjusting this potentiometer, R48, with a small screwdriver to obtain the specified ppm reading, leaving the SPAN pot set at 9.8.

For the 9.5 and 11.7 eV lamps see the Application Data Sheet or calibrations memo for the proper span pot settings and readings.

WARNING

Use great care when operating the analyzer with the readout assembly outside its case due to the presence of 1200 V DC.

When calibration is accomplished, turn the analyzer OFF and replace the readout assembly in its case.

Adjustment of R48 potentiometer is used only when a new lamp is installed. At all other times adjustment is accomplished using the SPAN control potentiometer.

If calibration cannot be achieved, see Section 6, Troubleshooting.

5.4 LAMP SIZE CHANGE

If different applications for the analyzer would require different size lamps, separate probes, each with its own eV lamp, must be used. A single readout assembly will serve for any of the probes. A change in probe will require resetting of the zero control and the span pot. Calibration should be checked to verify proper operation.

5.5 PROBE DISASSEMBLY/ASSEMBLY

WARNING

Turn the function switch on the control panel to the off position before disassembly. Otherwise high voltage of 1200 V DC will be present.

Disconnect the probe cable connector at the readout assembly. Disassemble the probe by first removing the exhaust screw at the base of the probe adjacent to the handle (see Figure 5-1). Grasp the end cap in one hand and the probe shell in the other, gently pull to separate the end cap and the lamp housing from the shell.

Hold the lamp housing with the black end cap upright. Loosen the screws on the top of the end cap, separate the end cap and ion chamber from the lamp and lamp housing.

CAUTION

> Care must be taken so that the ion chamber does not fall out of the end cap or the light source does not fall out of the lamp housing.

Turn the end cap over in the hand. Tap lightly on the top. The ion chamber should fall out of the end cap into the hand.

Place one hand over the top of the lamp housing and tilt slightly. The light source will slide out of the housing.

The amplifier board can be removed from the lamp source housing assembly (see Figure 5-2) by unsnapping the coaxial connector, J1, and then removing the retaining screw. The amplifier board will then slide out of the housing assembly.

Reassemble the probe by first sliding the lamp back into the lamp housing. Place the ion chamber on top of the lamp housing, making sure that the contacts are properly aligned. The ion chamber fits only one way.

If the ion chamber is to be replaced always use one identical to the one being removed. Check the aperture (small: 3.0 mm; large: 6.0 mm) at the top of the ion chamber and materials of construction (gold-plated or Teflon) to ensure proper replacement. See Parts List, Section 7.

Place the end cap on top of the ion chamber and replace the two screws. Tighten the screws only enough to seal the O-ring.

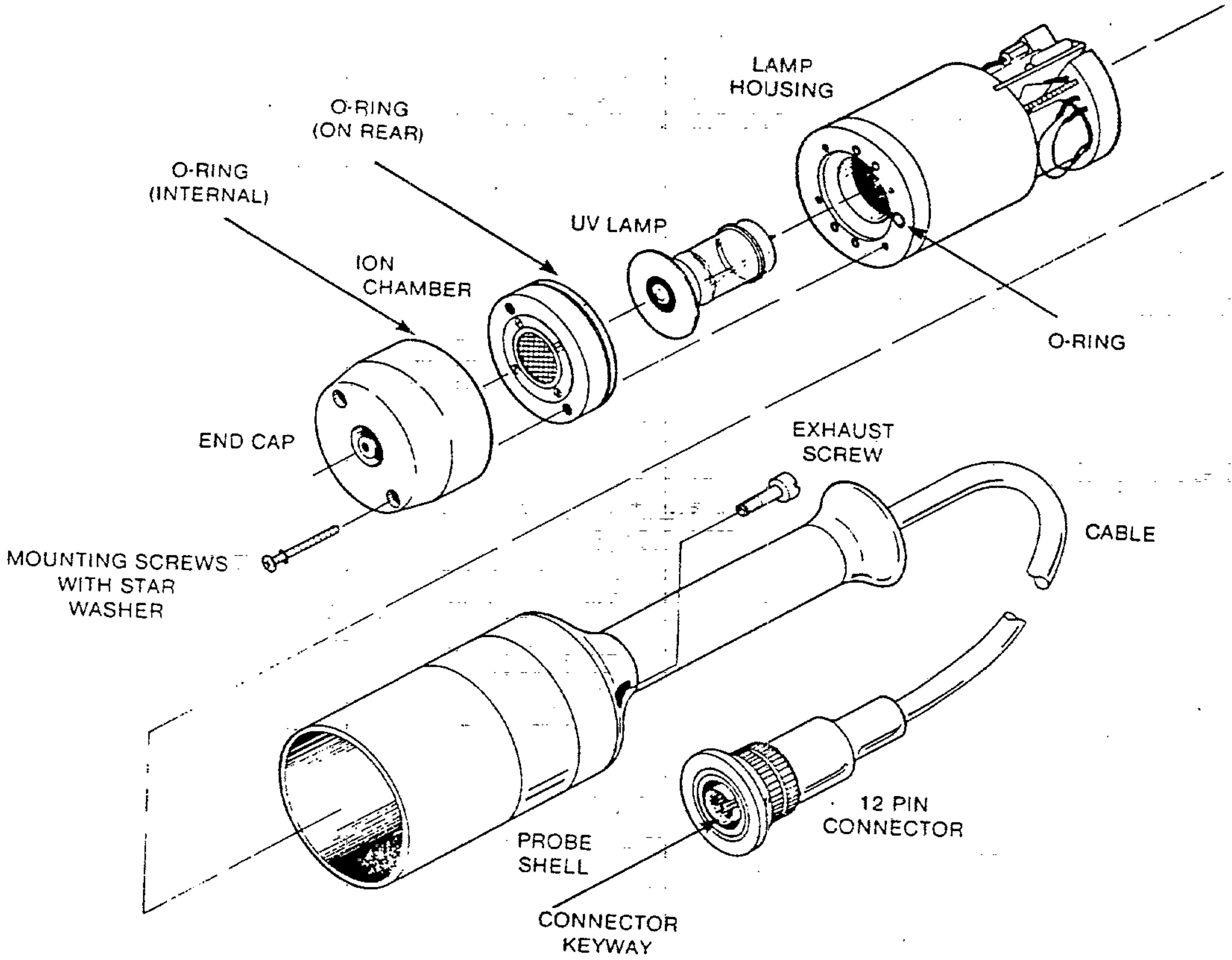


FIGURE 5-1
PROBE ASSEMBLY

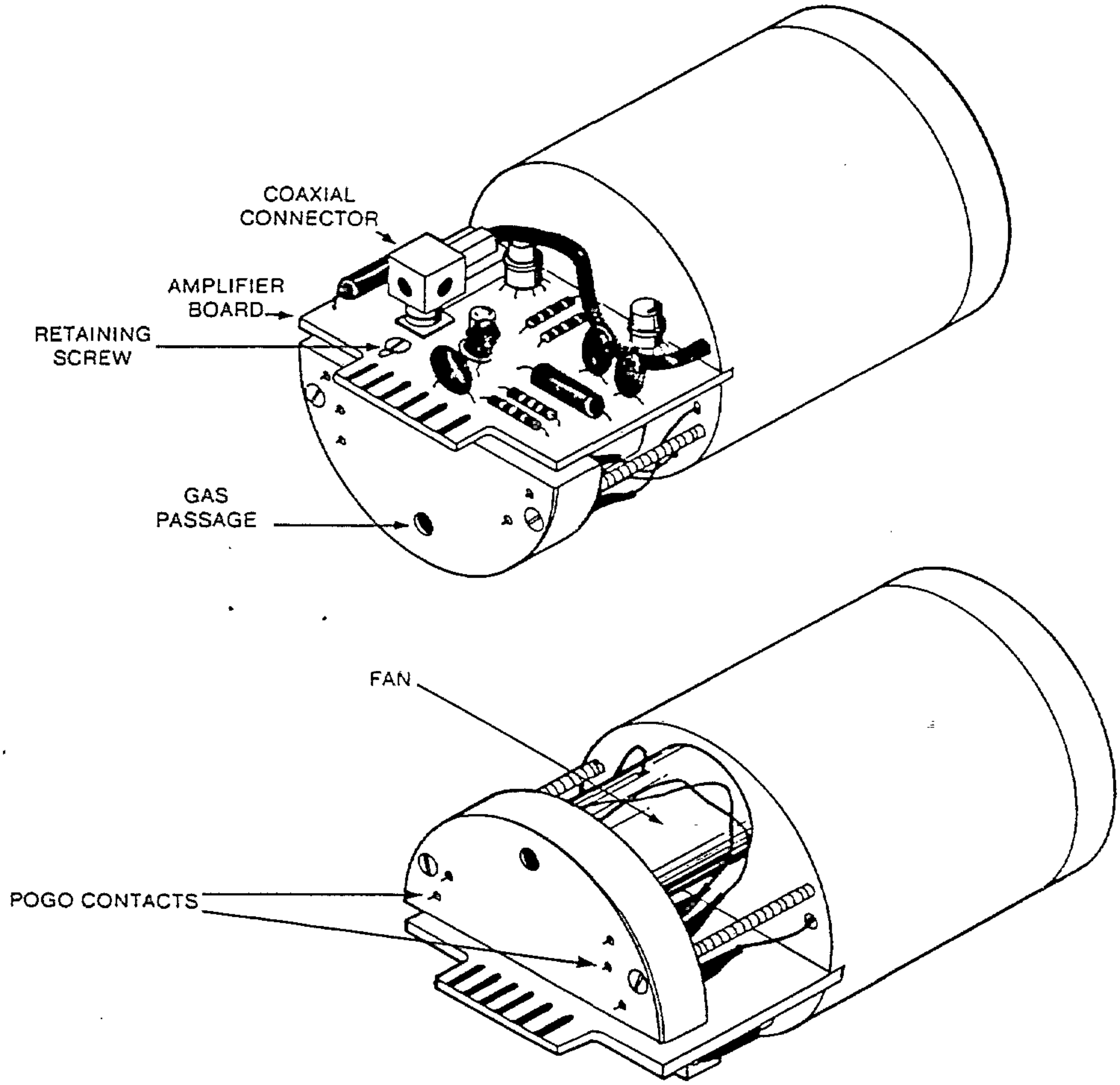


FIGURE 5-2
LAMP HOUSING ASSEMBLY

SECTION 5.5, PROBE DISASSEMBLY/ASSEMBLY cont.

CAUTION

Do not over-tighten these screws.

Line up the pins (pogo contacts) on the base of the lamp housing with the pins inside the probe shell. Gently slide the housing assembly into the probe shell.

The end cap should meet the probe shell evenly after final assembly. If not, the ion chamber may be installed wrong.

CAUTION

DO NOT FORCE the assembly into the shell. It fits only one way.

If it does not reassemble readily, remove and check pin alignment. Check to ensure pogo contacts are not bent. Refasten the exhaust screw at the base of the probe.

Align the 12 pin probe connector to the readout assembly and reconnect with a twisting motion until a click occurs. Check to ensure the high voltage microswitch is properly depressed. The lamp should light if the function switch is turned to any position except STANDBY.

5.6 READOUT DISASSEMBLY/ASSEMBLY

WARNING

Turn the function switch on the control panel to the OFF position before disassembly. Otherwise, high voltage of 1200 V DC will be present.

Disconnect the probe cable connection. Remove recorder jacks and cable or the plastic plug cap. Loosen the screw on the botton of the case and, holding the instrument by the bezel remove the case (see Figure 5-3).

a. The control assembly consisting of the Printed Circuit Board (PCB) and control panel can be separated from the readout assembly by the following steps:

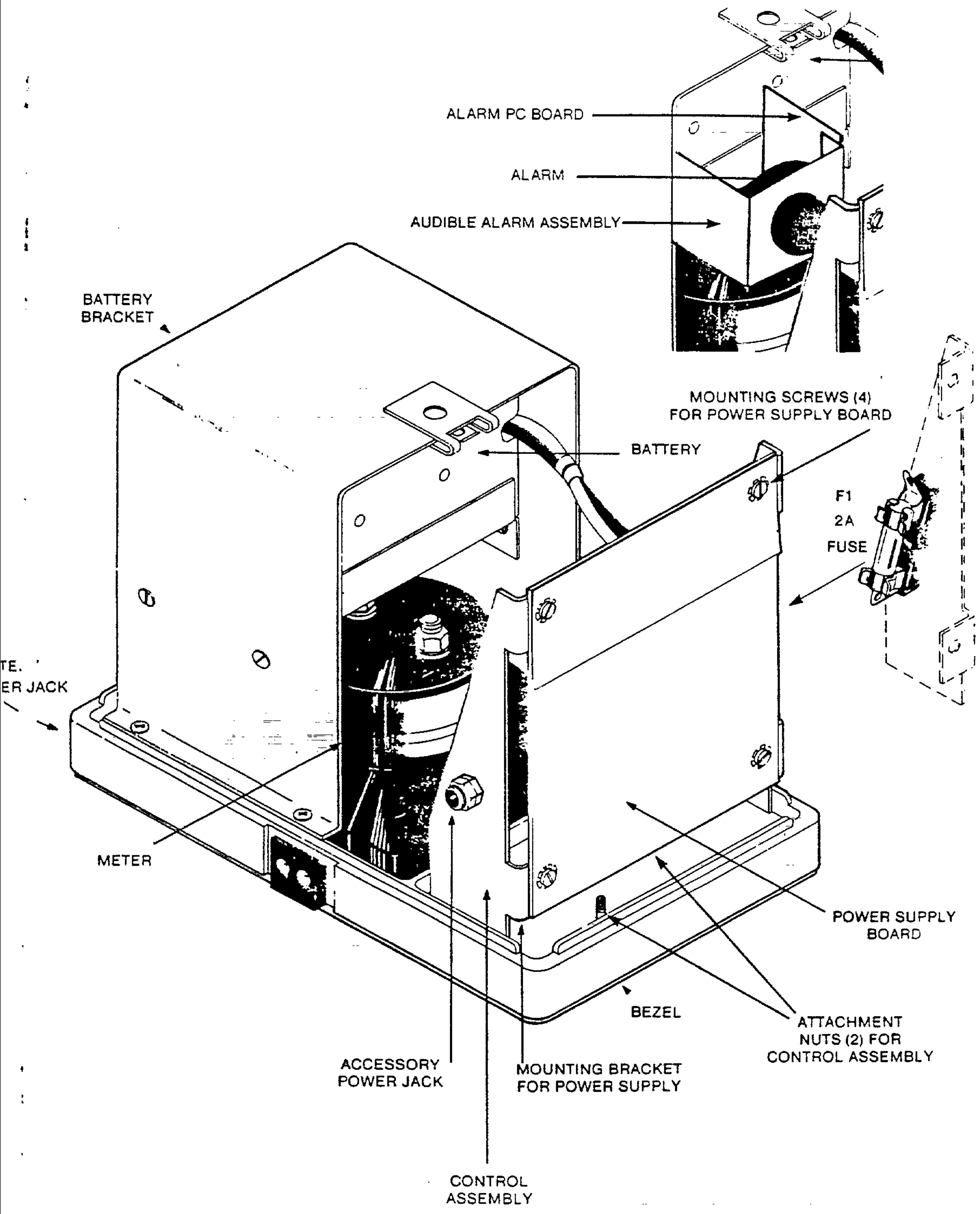


FIGURE 5-3
READOUT ASSEMBLY

1) Separate the Molex connectors in the cables to the control assembly.

2) Remove the two attachment nuts at the base of the assembly.

3) Remove the two screws at the top of the power supply board holding it to the assembly brackets.

4) Compress the brackets and slide the assembly thru the bezel. Remove a third screw at the lower corner of the board, if necessary.

b. The optional alarm assembly can be separated as follows

1) Disconnect the cable (P6/J6 of Figure 4-5)

2) Remove the two screws holding the alarm assembly to the battery bracket

Reassembly is accomplished by reversing the above procedure.

NOTE: Be sure the function switch on the control panel is in the OFF position before inserting the control module into the case. If not, the fuse can be blown or damage can result.

OPERATING PROCEDURES

DUPONT CONSTANT FLOW AIR SAMPLING

PUMP MODEL P4000

METHOD NOS. M-7A AND M-7B

1.0 PURPOSE

The following procedure details the operation of the Dupont P4000 Constant Flow Air Sampling Pump which is customarily used in various air sampling applications.

2.0 SCOPE

The Dupont P4000 has a flow rate range between 20 and 4000 cc/min. This pump features an electronic timing circuit that allows the user to program the unit for automatic shut off. Also, two light-emitting diodes (LED's) indicate if constant flow is maintained and whether the battery has been charged.

3.0 SAFETY PRECAUTIONS

3.1 Do not short battery.

3.2 Check filters for liquids to prevent pump contamination.

3.3 Do not overcharge.

3.4 Do not introduce solvents or liquids to "rinse out".

4.0 REFERENCE

E.I. Dupont de Nemours and Co., Operating Manual, 1981.

5.0 INSTRUCTIONS

5.1 Fully charge the battery before operating.

5.2 Remove control cover by turning thumbscrews counter-clockwise.

5.3 Set the programmable timing circuit in one of three modes:

A. To measure the elapsed time of sampling from the start of the pump to shutdown.

- o Set Switch 7 to manual position (MAN).
- o Set Switch 8 to normal position (NORM).
- o Set the six time switches to "on".

The pump will now run until it is manually turned off or until the battery is drained. The elapsed time can be determined by depressing the test button and noting which LSD timer indicator lights are energizing prior to turning it off.

B. To measure the elapsed time when the pump is turned on and off several times:

- o Set Switch 7 to manual position (MAN).
- o Set Switch 8 to interrupt position (INT).
- o Set Switches 1 through 6 to "on". The pump will run until it is manually turned off.
- o Depress the test button to determine the total sampling time.

C. To sample for a predetermined time period with automatic shutoff:

- o Set Switch 7 to automatic position (AUTO).
- o Set Switch 8 to interrupt position (INT).
- o Select the sample time period and program Switches 1 to 6 accordingly.
- o The pump will automatically shut off at the end of the programmed sampling period.

D. Turn on the "on-off" switch.

E. Wait a few seconds until the flow has stabilized.

F. Check the LED's. The battery check LED will light to indicate the battery has been charged. Charging time of 14 to 16 hours is required to ensure a fully charged battery.

G. Attach collection device to the inlet hose barb.

H. Attach pump to user's belt for personal sampling. Position collection device near user's breathing zone. Use pump for area monitoring by positioning the collection device appropriately.

I. Record:

- o Date.
- o Pump serial number.
- o Flow rate.
- o Unusual conditions (weather, interrupted operation).
- o Employee's name.
- o Survey supervisor.

J. Retrieve the pump at the end of the sampling time. Observe the flow control LED before turning off pump. If the LED is lit, flow has been restricted during the sampling period and the test is invalid.

K. Turn the unit off and record:

- Elapsed sampling time represented on the LED timer indicator lights.
- Flow rate, after rechecking it.
- Any unusual conditions that occurred during the sampling period.

L. Prepare the collection device for analysis.

M. Set up the pump to recharge the battery in the case for 14 to 16 hours.

Method M - 7A
Rev. 0
May, 1984

REQUEST FOR APPROVAL OF PHOENIX METHOD NO. M - 7A DUPONT SAMPLING PUMP OPERATION

Don C. Wolski, Requester	Date
Ann G. Federoff, Mgr., Q.A.	Date
Terrence A. Shannon, Vice President Phoenix Safety Associates, Ltd.	Date
Anthony A. Fuscaldo, Ph.D., President Phoenix Safety Associates, Ltd.	Date

CALIBRATION

DUPONT CONSTANT FLOW AIR SAMPLING PUMP

MODEL P4000

METHOD NO. M-7B

1.0 PURPOSE

Method M - 7B describes the procedure to properly calibrate and provide routine maintenance for the Dupont P4000 Air Sampling Pump.

2.0 SCOPE

Generally, the Dupont P4000 maintains it s flow rate for long periods of time, however, daily calibration is necessary to obtain accurate test results. The bubble tube calibration technique is described by the following procedure to set the flow rate to one of it s three ranges.

3.0 REFERENCES

E.I. Dupont de Nemours & Co., Operating Manual, 1981.

4.0 PROCEDURE

4.1 Set up bubble tube apparatus. Remove control cover of pump and connect pump and bubble tube, with a representative length of tubing. Be sure to have a sampling filter or other device you will be sampling with in line to account for drag.

4.2 Set the flow rate for the pump in the desired range according to the following.

A. Low Flow Range 20-500 cc/min.

- o Rotate the flow range selector valve three turns counterclockwise from the fully closed position.
- o Align the drive belt in the low flow position.
- o Rotate the flow rate adjusting valve until the desired flow is reached.

B. Intermediate Flow Range 500-2000 cc/min.

- o Rotate the flow range selector valve clockwise until it is closed. Do not overtighten because damage could result.
- o Align the drive belt in the low flow position.
- o Rotate the flow rate adjusting valve until the desired flow is reached.

C. High Flow Range 2000-4000 cc/min.

- o Rotate the flow range selector valve clockwise until it is closed. Do not overtighten.
- o Align the drive belt in the high flow position.
- o Rotate the flow rate adjusting valve until the desired flow is reached.

4.3 Adjust the pump to the desired nominal flow rate. Check the water manometer.

4.4 Start a soap bubble in the buret and measure the time, with a stopwatch, that it takes to traverse two calibration marks. For a 1000-mL buret, a convenient calibration volume is 500 mL. Repeat the determination at least twice more. Average the results and calculate the flow rate by dividing the calibration volume by the average time.

$$\text{Flow Rate} = \frac{\text{Volume}}{\text{Time}}$$

4.5 Record the following data:

a) volume measured
b) elapsed time
c) pressure drop
d) air temperature
e) atmospheric pressure
f) serial number of the pump
g) pump model
h) date and name of operator

Method M - 7B
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REQUEST FOR APPROVAL OF PHOENIX METHOD NO. M - 7B DUPONT SAMPLING PUMP CALIBRATION

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OPERATING PROCEDURES

DUPONT AIR SAMPLING PUMP

MODEL P200A

METHOD NOS. M-8A AND M-8B

1.0 PURPOSE

This procedure details the procedure to be followed when using the DuPont P200A Air Sampling Pump in both personal and area monitoring.

2.0 SCOPE

Due to it s lightweight and compactness, the DuPont P200A is an excellent tool for personal sampling applications. It can be worn on the belt and with a length of Tygon tubing can sample air at a worker's breathing zone. It can also be utilized in the field as an area monitoring pump by securing it to fixed sampling location.

3.0 REFERENCE

E.I. DuPont de Nemours & Co., Operating Manual, 1981.

4.0 PROCEDURE

4.1 Remove fully charged calibrated pump from case and connect sample tubing.

4.2 Turn on pump to ensure that it is operating. (It generally takes a few seconds to begin pumping and then a few more to stabilize).

4.3 Secure pump to sampling station.

- If pump is to be used for personal sampling, attach to the person's belt. Then with a length of tubing strung over the person's back, tape the end to the person just below the chin. If possible, use a sampling tube holder.
- If pump is to be used for area monitoring, select a representative sampling location and secure the pump there. It will probably be necessary to use only a short length of tubing between the sampling medium and the pump.

4.4 Turn on pump and record time.

4.5 Place control cover on pump with the aid of a small allen key.

4.6 At the end of the sampling period, remove control cover and shut off pump. Record time.

4.7 Remove and seal sampling medium. Prepare samples for transportation to laboratory.

4.8 Disassemble sample tubing and replace pump in case.

4.9 When possible, recalibrate pump to determine the average flow rate and volume of air sampled.

REQUEST FOR APPROVAL OF PHOENIX
METHOD NO. M - 8A
DUPONT SAMPLING PUMP OPERATING PROCEDURES

Don C. Wolski, Requester — Date

Ann G. Federoff, Mgr., Q.A. — Date

Terrence A. Shannon, Vice President
Phoenix Safety Associates, Ltd. — Date

Anthony A. Fuscaldo, Ph.D., President
Phoenix Safety Associates, Ltd. — Date

1.0 PURPOSE

Method M - 8B describes the procedure to be followed when calibrating and providing routine maintenance on the DuPont Air Sampling Pump, Model P200A.

2.0 SCOPE

The DuPont Model P200A is a compact personal monitoring pump with an adjustable flow of 50 - 200 ml/min. It is battery operated and with a fully charged DC source can be operated for 8-hour shifts with virtually no decrease in flow rate. The Bubble Tube calibration technique is described here and should be used to calibrate the DuPont Model P200A.

3.0 REFERENCE

E.I. DuPont de Nemours & Co., Operating Manual, 1981.

4.0 PROCEDURE

4.1 Set up bubble tube apparatus on side of carrying case.

4.2 Connect pump to bubble tube with tygon tubing with representative sampling medium in line to account for drag.

4.3 Remove control cover and switch pump on.

4.4 Place soap solution in contact with open end of bubble tube to initiate bubble flow.

4.5 Repeat step 4.4 until inside of tube is coated with solution and bubbles can travel up the entire length of tube unobstructed.

4.6 Once you have determined your flow rate, select a volume which can be obtained by reading any two graduated marks on the bubble tube. By using the equation:

$$\text{Time} = \frac{\text{volume}}{\text{flow rate}}$$

the amount of time permitted for the bubble to rise from one graduated mark to another can be calculated. This time can be measured by a stopwatch.

4.7 By turning the screw in the top right hand corner of the pump, the flow rate can be increased or decreased. Adjust this screw until the bubble passes through the two marks in the above mentioned time.

4.8 Repeat this step three times to obtain an average flow rate.

4.9 After sampling, repeat the entire calibrating sequence to obtain an average flowrate which can be combined with the average in 4.8 to obtain a representative flowrate for the entire sampling period.

5.0 MAINTENANCE

5.1 Recharging of the batteries should occur prior to any sampling. Customarily, for every hour of use the pump should be placed on charge. If the pump has not been used recently, it is recommended that it be left on charge for 10-16 hours prior to use.

5.2 Tygon tubing should be inspected prior to each use for gross contamination.

Method M - 8B
Rev. 0
May, 1984

REQUEST FOR APPROVAL OF PHOENIX
METHOD NO. M - 8B
DUPONT AIR SAMPLING PUMP CALIBRATION

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OPERATING INSTRUCTIONS

DUAL HEAD AIR CADET PUMP

METHOD NO. M-9A

Method No. M - 9A

1.0 INTRODUCTION

The Dual Head Air Cadet pump is designed for pressure, suction, and gas circulating applications. It s diaphragm-operated design minimizes stress, wear, and heat buildup. Chemical resistance is increased by the use of Noryl, Viton and Teflon in the construction of the pumping chamber which the media being pumped will come in contact with.

The Model 7530-60 is capable of a flow rate of 10 l/min. which makes it an excellent tool in air sampling determinations which require high volume sampling (i.e. Asbestos sampling). By connecting the two heads in parallel, the flow rate can be doubled. Polyethylene fittings enable 3/16" or 3/8" I.D. flexible tubing to be used for sampling.

The brushless motor is thermally protected, and has sealed ball bearings. No regular maintenance is required.

2.0 PRECAUTIONS

2.1 The pump should be grounded with the aid of the three prong plug and an outlet that meets all local codes and ordinances.

2.2 The motor, when operated will run very hot. Use caution when moving pump during operation and immediately thereafter.

2.3 Do not operate pump when pressure ports of both heads are in a blocked condition as this may damage motor.

3.0 REFERENCE

Cole-Parmer Instrument Co., <u>Operating and Maintenance Instruction Manual</u>, Chicago, IL 1983.

4.0 OPERATION

4.1 Remove pump for packaging.

4.2 Place a single turn of tape on polethylene fitting threads and assemble into pump port. Hand tighten only.

4.3 Connect tubing to pump. To minimize noise level, use three foot lengths of tubing at both ends of pump. Remember, changes in tubing diameter, fittings, bends and obstructions will increase pressure and decrease flow.

4.4 Place pump in representative sampling location.

4.5 Connect sampling device and secure to a stationery object to prevent vibration.

4.6 Turn pump on and record start time.

4.7 An internal thermal overload switch may trip during operation if something happens to the pump. Record the time, check to see if everything is normal, allow motor to cool for approximately 30 minutes then restart.

4.8 Turn pump off and record time. Disconnect the sampling device and prepare for shipment to lab.

4.9 Allow motor to cool, remove and store tubing cover parts to keep dust and dirt from contaminating pump.

4.10 Wipe power cord and pump with a damp cloth, store in a clean, dry, safe area.

INSTRUCTION MANUAL

INDUSTRIAL SCIENTIFIC

COMBINATION COMBUSTIBLE GAS/ OXYGEN MONITOR

MODEL MX241

AND

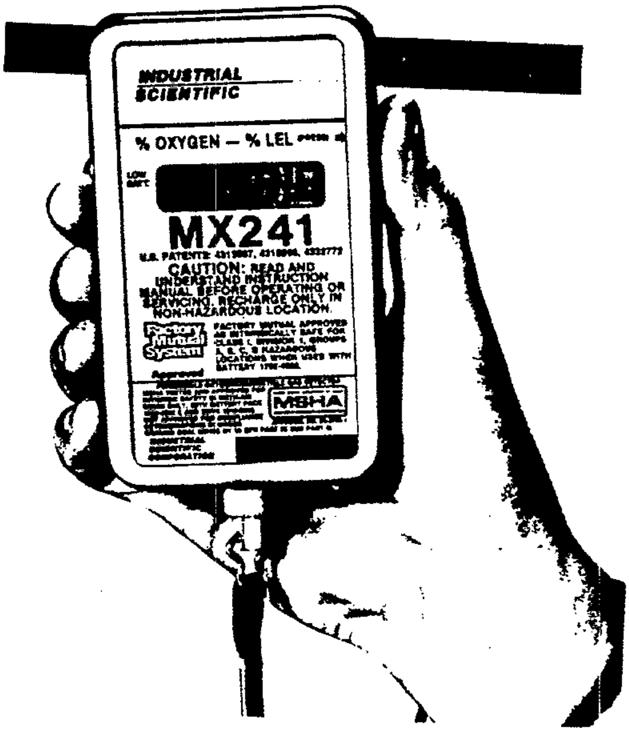
SAMPLING PUMP

MODEL SP201

INDUSTRIAL SCIENTIFIC

Model MX241

Combination Combustible Gas/ Oxygen Monitor



Instruction Manual

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1.0 GENERAL INFORMATION

1.1 AIR AND GASES

Air is a mixture of gases. Clean, dry air consists of 78.08 volume percent nitrogen, 20.95 volume percent oxygen, and 0.87 volume percent other gases including argon and carbon dioxide. Life, combustion, and various chemical reactions are supported by oxygen. Human beings can tolerate moderate variations in the amount of oxygen in the air. Breathing becomes labored when the air contains only 16% oxygen. However, U.S. Department of Labor - OSHA (General Industry Safety and Health Standards 29 CFR 1810.94 (d) (vi) requires the use of air-supplied respirators to provide adequate oxygen when the concentration of oxygen is less than 19.5%. Oxygen deficiency can be the result of the displacement of oxygen by other gases, aerobic bacterial activity, combustion, and the oxidation of metal.

A mixture of air and a combustible gas or vapor (hereinafter the term "gas" shall be understood to mean combustible gases and/or vapors) will support the propagation of a flame away from a source of ignition only when the concentration of the gas, as a percent of the total volume of the mixture, is within the flammable range of that specific gas or combination of gases. An air/gas mixture in which the concentration of gas is below the flammable range will be too lean to propagate combustion. The flammable range has a lower limit and an upper limit; i.e., the lower flammable limit (LFL) and "lower explosive limit" (LEL) are equivalent, as are "upper flammable limit" and "upper explosive limit".

1.2 FUNCTIONS

1.2.1 Model MX241 is a continuous duty oxygen monitor and combustible gas monitor combined in a compact, rugged, easily operated and maintained instrument. It has a 3 1/2 digit liquid crystal display (LCD), an audio indicator (alarm buzzer), solid state circuitry, and rechargeable nickel cadmium battery pack in a stainless steel case.

1.2.2 Combustible Gas Detection is accomplished by means of a catalytic diffusion type sensor that consists of two wound platinum wire elements covered with porous refractory. One element is active, the other is a reference. The combustible gas concentration as a percent of the LEL is shown by the display when the push-button switch in the right side of the case is pressed. An integral audible alarm is provided which will sound if the concentration of combustible gases exceeds a set point. The alarm is factory set at 20% LEL of hexane. It can be reset to other levels to meet individual user needs. The alarm operates independently of the display. The alarm is field adjustable between 0% LEL and 55% LEL.

1.2.3 Oxygen Monitoring is accomplished by means of a micro fuel cell that provides a current proportional to the concentration of oxygen in the air. The interaction of electrodes and electrolyte within the fuel cell depends on the presence of oxygen. The LCD constantly displays the concentration of oxygen as a percent of the total atmospheric volume. (The oxygen readout is replaced by the combustibles readout when the switch in the right side of the case is pressed.) The alarm sounds if the concentration of oxygen falls below a preset level. The set point is adjustable between 17% and 30% oxygen. The alarm is factory set at 19.5%.

1.2.4 Headphone Driver

The MX241 will accept a headphone driver unit that provides an output for a headphone to be worn by the user of an MX241 who is in an area where ambient noise would prevent him from hearing the instrument's alarm. The recommended unit is an AD200, *Industrial Scientific Corporation* Part Number 1810-0248.

1.3. SPECIFICATIONS

1.3.1 Physical and Component

Case: Stainless Steel, dust tight and splash resistant

Dimensions: 121mm x 70mm x 38mm (4.75 x 2.75 x 1.5 inches)

Weight: 605 grams (21 ounces)

Sensors: Combustibles - catalytic, diffusion type
Oxygen - temperature compensated galvanic electrochemical cell

Power Supply: 4.8 volts (nominal), 750 mA hour rechargeable, nickel cadmium battery pack

Display: 3 1/2 digit liquid crystal

Alarm: Audio indicator (buzzer)

Battery Life: More than 1000 charge/discharge cycles; Operation Cycle: 8 hours 'On', 16 hours 'Recharge.'

1.3.2 Performance

Oxygen Measuring Range: 5 to 30%

Combustibles Measuring Range: 0 to 100% LEL

Accuracy: ± 0.7% O_2 by volume in range of 16-23
± 1.2% O_2 by volume in range of 5-30
± 3% LEL in range 0-30% LEL
± 10% of actual concentration in range 30-100% LEL

Precision: 0.1% oxygen
1% LEL Combustibles

Typical Response Time: Combustibles, 90% of value in 30 seconds
Oxygen Sensor, 62% of change in 30 seconds

1.3.3 Environmental Factors

Temperature Range: 0 C to 40 C

Humidity Range: 10 to 90% RH

Splash Resistant

Light Levels: Bright sunshine to dark interior

1.4 WARNINGS AND CAUTIONARY STATEMENTS

Certain conditions or failure to observe certain necessary procedures will impair the performance of the instrument. These are outlined below to be read and understood by any person using the instrument.

1.4.1 Oxygen deficient atmospheres will cause erroneous low determinations of the combustible gas content of the air.

1.4.2 Oxygen enriched atmospheres will cause erroneous high determinations of the combustible gas content of the air.

1.4.3 Verify the calibration of the combustible detecting mode of the instrument after use where the combustible gas content as a percent of the LEL was 100% or greater. Long continuous use (hours for one test) at high LEL concentrations (50% to 100%) or high humidities (90% or 100% RH) may cause hydroxylation (temporary blinding of catalytic sites by hydroxide groups) resulting in reduction of sensitivity and erratic behavior, including inability to calibrate. If this occurs, the sensor should be replaced.

1.4.4 Silicone compound vapors and sulfur compound vapors will cause desensitization of the combustible sensor and thus cause erroneous low determinations. Verify the calibration of an instrument that has been used where these vapors were present before that instrument is relied upon for accurate measurements. Replace the sensor if the instrument cannot be calibrated.

1.4.5 Prior to each day's use, the instrument should be calibrated to a known concentration of combustible gas equivalent to 25 to 50% LEL fullscale concentration. Calibration gases are available from the local distributor of Industrial Scientific Corporation products.

1.4.6 The oxygen sensor's output is directly proportional to the partial pressure of oxygen in the air. Changes in the total pressure of the atmosphere due to changes in altitude will bear on the instrument's determination of the air's oxygen content. Calibrate the oxygen monitor mode of the MX241 at the altitude at which it will be used.

1.4.7 Any rapid up-scale reading followed by a declining or erratic reading, or reading greater than 100% LEL, may indicate a gas concentration beyond the accurate response range of the sensor. Either take immediate corrective action to eliminate this potential hazard; or, withdraw from it.

1.4.8 Readings that are either negative or greater than 100% LEL may indicate an explosive concentration of combustible gas. These readings may also indicate instrument malfunction.

1.4.9 Obstruction of the screened sensor ports will cause erroneous low readings. These screens must be kept clean.

1.4.10 Calibration for oxygen should be made at the approximate temperature at which the unit will be used. Large changes in temperature cause erroneous readings.

1.4.11 Alarm may be difficult to hear or even drowned out in high noise ambients. Use the AD200 (P/N 1810-0248) in conjunction with headphones or earphones in these areas.

2.0 OPERATION

2.1 Initial

Unpack and visually inspect the instrument for physical damage. When received, the MX241 shipping carton should contain these items:

1 - Model MX241 Gas Measuring Instrument (1810-0230)
1 - Model MX241 Instruction Manual
1 - Calibration Cup w/Hose (1700-6933)
1 - 5/64 hex key (1700-7147)
1 - Screwdriver (1700-3567)

Account for each of these items before the carton is discarded. If the instrument is damaged, contact your local Industrial Scientific Corporation Distributor or call direct to (412) 788-4353 or 800-338-3287.

Become familiar with the location of the instrument switches and externally accessible potentiometers (pots). These are identified in Figure 1.

To turn on the MX241, unscrew the knurled collar on the carrying strap mounting post. The calibration cover may now be pulled away from the instrument case top. A pin on the calibration cover disengages from the on/off switch inside the case, and the instrument turns on.

Initially, the display will indicate a very high number. For example, 88.0 percent oxygen. This is due to the fact that the oxygen sensor puts out extraordinarily high signal when it is first turned on. A new oxygen cell may require as long as 15 minutes before it stabilizes in the 21% range.

With the knurled collar unscrewed, the calibration cover may be spun aside to allow access to the adjustment potentiometers inside the instrument. The combustibles zero adjustment is on the left near the strap mounting post. The combustibles span adjustment and the oxygen adjustment are accessed through a common hole on the right.

After calibrating the instrument, spin the calibration cover so that its pin is in the access hole for the span and oxygen adjustment. Tighten down the knurled collar. The instrument is now ready for use. The readout will continually display the percentage of oxygen present. Combustible gases are also con-

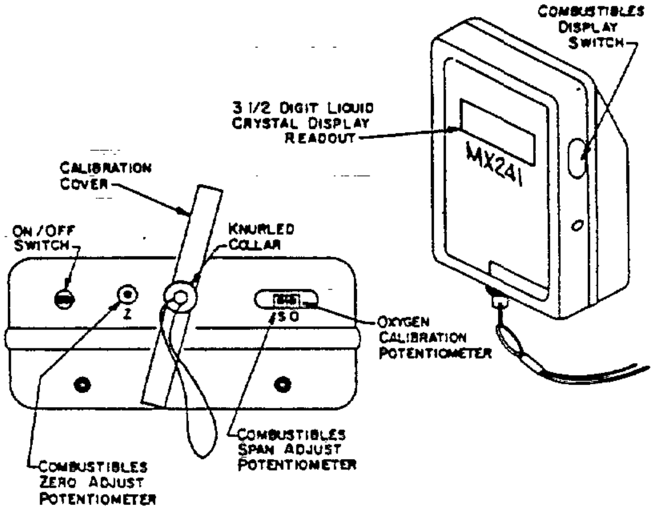

Figure 1.
Location of Instrument Controls and Adjustments

stantly monitored. The display may be converted from oxygen to combustibles by depressing the recessed switch to the right of the readout on the side of the case.

BEFORE PROCEEDING TO USE THE INSTRUMENT, CHARGE THE BATTERIES AND CALIBRATE BOTH MEASURING MODES.

NOTE: Instrument must be turned off before charging.

2.2 Charging the Batteries

The MX241 requires a constant 75 milliamperes charging current. A completely discharged battery's full potential will be restored by 16 hours of charging. A Single Unit Charger, Part Number 1810-0123, and a Five Unit Charger, Part Number 1810-0115, are available from the local distributor of Industrial Scientific Corporation products. There is no danger of overcharging the batteries when using either of the above ISC 200 Series Constant Current Battery Chargers.

Apparent reductions in battery capacity may result from repetitive use patterns. A fully charged battery that does not deliver energy for at least 8 hours continuous monitoring may have developed a "memory" condition. To eradicate this, entirely discharge and then fully recharge the battery. The memory effect can be avoided by using the MX241 so that the battery is discharged to varying depths.

2.3 Calibration Check

The MX241 must be checked to insure proper operation and calibration. Refer to Section 4.2 for calibration procedure.

3.0 THEORY OF OPERATION AND TROUBLESHOOTING HINTS

3.1 Description of Subassemblies

3.1.1 Oxygen Sensor (1701-9282)

The MX241 uses an electrochemical oxygen sensor which converts the oxygen of the atmosphere to a current signal. This sensor, enclosed in a protective vinyl sheath, is located on the beveled surface of the MX241 case bottom. A small block assembly gives the sensing surface of the cell access to the atmosphere.

The oxygen cell does respond to temperature variation; particularly to rapid transients. Signal transients of up to a half hour may occur when the oxygen cell is taken through an abrupt change of temperature. The reaction of the cell is somewhat better for temperature decreases than for temperature increases.

The cell produces a current that is proportional to the percentage of oxygen in the atmosphere from 5 to 30% oxygen. The signal will gradually decrease in magnitude as the cell ages.

The sensor needs to be replaced when the correct oxygen concentration can no longer be obtained by adjustment of the oxygen span potentiometer. Consult Section 4.3 for the proper replacement procedure.

3.1.2 Combustible Gas Sensor (1702-5172)

The combustible gas sensing element of the MX241 is housed in an aluminum block attached to the beveled surface of the case bottom. Model MX241's gas detecting sensor consists of two elements, each of which is a specially wound platinum wire coil covered with a porous refractory material. One of the elements is impregnated with a catalyst to make it active in oxidizing combustible gases. The other element is impregnated with materials that will not allow it to oxidize gases but will allow it to respond to ambient conditions of temperature and humidity. This second element is used as a reference.

In the circuitry of the MX241, the two elements of the sensor compose one half of a balanced Wheatstone bridge When the instrument is operating, current heats the sensor elements. Air, or, when combustible gases are present, air/gas mixtures, diffuse into the sensor chamber and surround the elements. Although the air/gas mixture may not be within the flammable range, the catalyst on the active element oxidizes the gas mixture near the surface of the element. The oxidation of the mixture causes an increase in the temperature of the active element that is proportional to the amount of combustible gas in the air. The reference element does not cause oxidation and no temperature increase occurs on it. As the temperature of the active element increases, so does its resistance. The resultant bridge imbalance produces a signal proportional to the gas concentration in the air. Analog to digital conversion circuitry displays the signal as a number that is the percent of the lower explosive limit (% LEL).

If one of the beads becomes inoperative, the instrument cannot be recalibrated. These malfunctions are indicated by the display going blank and the audible alarm being triggered. The sensor is replaced as a unit (refer to Section 4.3) and comes already installed in its aluminum block.

3.1.3 MX241 Mother Board (1701-0786)

The MX241 mother board contains most of the signal processing electronics for the instrument. It mounts on three brackets attached to the case bottom. Most of the wires coming from the oxygen sensor, combustible sensor, buzzer, battery pack, earphone contacts, and charging jack attach to this board. This board also holds the adjustment potentiometers for the combustible and the oxygen sensors. These face one end of the case and may be accessed through holes in the case top. The on/off switch for the instrument is also facing the case end in order to engage the calibration cover. The switch which converts the readout from oxygen to combustible is on the upper right-hand side of the board. The electronics on this board receive and condition the signals from the oxygen and combustible sensors for transmission to the display board. In addition, the control electronics for the switching power supply (which provides a regulated voltage to the combustible sensor) are on the mother board.

3.1.4 Regulator Board (1702-4795)

The switching components of the power supply for the combustible gas sensor are located on a separate board mounted on four pins on the underside of the mother board. This small board is the regulator board and protrudes down into the open area of the case bottom beside the charging jack.

3.1.5 Display Board (1701-0844)

A liquid crystal display board is mounted on standoffs above the mother board. This board contains the A/D converter-liquid crystal display driver integrated circuit which converts the sensor signals to the digits that are displayed through the faceplate of the case. This board also contains the analog switch package which allows the control electronics of the mother board to drive the display into the various readout and malfunction modes.

3.1.6 Auxiliary Control Board (1701-9076)

A small auxiliary control board is mounted on an adhesive foam pad on the side of the buzzer with wires connecting back to the Mother Board. This board contains a circuit which causes a brief alarm tone in the earphones or headphones when an AD200 is being used with the MX241. This is to test the integrity of the alarm circuit.

This board also has a power on/off circuit that controls the oxygen sensor. When the instrument is not in use (i.e., turned off), this circuit disconnects the load resistors from the oxygen sensor, prolonging the life of the sensor.

3.1.7 Audible Alarm (1702-3896)

The MX241 is capable of warning the user of danger conditions even if the user is not looking at the instrument display. This is accomplished by sounding a buzzer which is attached to the beveled surface of the case bottom. The buzzer generates 75 dBA and should be suitable for most applications.

3.1.8 External Audible Alarm

For those instances where a high noise environment is encountered, contacts are provided on the back of the MX241 case for use with the AD200 Audio Driver, P/N 1810-0248. When used in conjunction with the AD200, these contacts will sound a tone in an earphone or headphone worn by the person carrying the instrument, serving as a backup to the warning buzzer.

4.0 REGULAR MAINTENANCE

The instrument requires no short term maintenance other than regular calibration and recharging of the batteries. Use a soft cloth to wipe any dirt, oil, moisture, or foreign material from the instrument.

4.1 Screen Cleaning and Replacement

The stainless steel screens are to protect the audible alarm and the detectors from direct impact. The screens can be removed by taking out the three screws which hold the bezel onto the beveled surface of the instrument. Once removed, the screens can be cleaned by shaking them or by forced air. Solvents should **not** be used since they may interfere with the detectors.

4.2 CALIBRATION PROCEDURE

4.2.1 Oxygen Detector

Loosen the knurled collar on the strap mounting post and swing aside the potentiometer access cover. Allow 15 minutes for the oxygen detector to equilibriate before calibration. If the sensor has never been used, the equilibration time may be slightly longer, but after the instrument is used a few times, the time is reduced dramatically. The delays are due to the circuitry which disconnects the oxygen cell when it is not being used to extend the working life of the sensor.

In clean air, known to have the composition described in Section 1.1, adjust the oxygen calibration potentiometer (through the hole labeled "o") slowly clockwise so that the oxygen readout goes downward. The alarm should sound clearly at 19.5% oxygen or at the percentage set by the user. (See Section 4.2.4). Final calibration of the oxygen readout should only be done in free air if the user is sure that the air contains the normal 20.9% oxygen. The readout should then be adjusted to 20.9. If there is any doubt of the oxygen content of the air, calibration gas of a known percentage of oxygen in nitrogen should be used. Introduce the test gas at 0.5 (± .05) liters per minute through the calibration cup (ISC P/N 1700-6933). (Refer to Figure 3). Allow one minute for the oxygen sensor to respond to the gas. Adjust the readout to show the known percentage of oxygen.

4.2.2 Combustibles Detector

Before calibrating the combustibles detector, switch on the instrument and allow the sensor to warm up for 15 minutes. In clean air, switch the instrument display to combustibles. Adjust the zero potentiometer, (through the hole labeled "z") to obtain a readout 000.

Use the calibration cup (ISC P/N 1700-6933) to apply combustible gas of a known concentration to the instrument. The rate of gas flow should be 0.5 (± .05) liters per minute. (Refer to Figure 3). Switch the instrument display to combustibles. Use the span potentiometer (through the hole labeled "s") to set the readout to the percent LEL corresponding to the known gas concentration. Variations in the flow rate will cause inaccurate calibration of the instrument.

Remove the test gas and wait for approximately one minute for the gas to completely disperse. Check that the instrument readout returns to 000. Place the potentiometer access cover in its operating position and tighten the knurled collar.

If the instrument cannot be calibrated, the span potentiometer may be at such a low setting that the instrument cannot respond properly. Turn the span potentiometer approximately 15 turns counterclockwise, and then repeat the calibration procedure described above. Note that the calibration procedure calls for the adjustment of the zero potentiometer first. The span potentiometer should not be readjusted until the zero potentiometer is properly set.

The MX241 is calibrated on hexane at the factory. It must be recalibrated on the actual gas being monitored in order to obtain the accuracy specified in Section 1.3 of this manual.

4.2.3 Field Adjustments to Alarm Settings

The MX241 is shipped with the alarm levels factory set at 19.5% oxygen and 20% LEL. The user may change either or both of these settings if desired. The oxygen alarm level may be set anywhere in the range 17% to 55% oxygen. The combustibles alarm is adjustable in the range 0 to 55% LEL.

Adjustments to the factory settings of these alarm levels should only be made by qualified repair technicians. Misadjustment of these levels could seriously impair the performance of the instrument.

The case top of the MX241 must be removed to access the alarm setting potentiometers. Refer to Section 4.3.1.1 for instructions in removing the case

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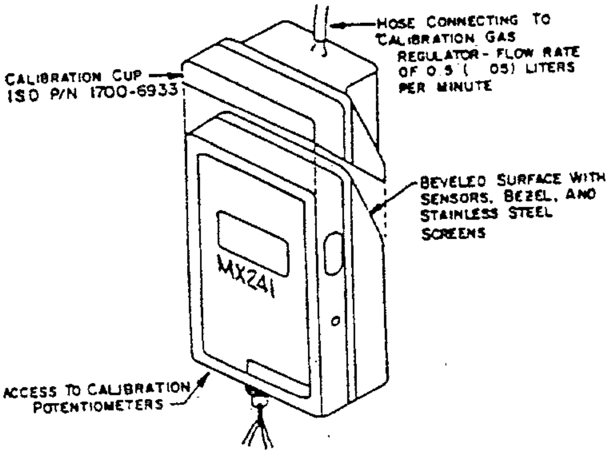

Figure 2.
Calibration of an MX241

top.

The alarm setting potentiometers are P2 and P6, the circular potentiometers on the lower right edge of the mother board (See Figure 4). They are sealed in place with a spot of Glyptal. This will break free with the first turning of the potentiometer.

To reset the low oxygen alarm, begin by turning potentiometer P2 fully clockwise. Use the oxygen calibration potentiometer to set the readout to the reading corresponding to the desired new alarm level. If a setting higher than 22% is desired, it may be necessary to use a test gas of high oxygen concentration to increase the output signal of the oxygen sensor.

Remember that the new alarm setting cannot be higher than 55% oxygen or lower than 17% oxygen.

With the readout displaying the desired alarm set point, slowly turn potentiometer P2 counterclockwise. The buzzer will eventually sound. Slowly turn P2 back and forth to set it as precisely as possible to the point where the buzzer is just on the threshold between sounding and not sounding.

It is strongly recommended that P2 be sealed in place by applying a drop of Glyptal or other adhesive to prevent accidental movement of the alarm setting.

The oxygen readout should be fully recalibrated before using the instrument.

To reset the high combustible alarm, begin by turning potentiometer P6 fully counterclockwise. Use the combustibles span and zero calibration potentiometers to turn up the combustibles readout until it displays the reading corresponding to the desired new alarm level.

Remember that the new alarm setting cannot be higher than 55% LEL.

With the readout displaying the desired alarm setpoint, slowly turn potentiometer P6 clockwise. The buzzer will eventually sound. Slowly turn P6 back and forth to set it as precisely as possible to the point where the buzzer is just on the threshold between sounding and not sounding.

It is strongly recommended that P6 be sealed in place by applying a drop of Glyptal or other adhesive to prevent accidental movement of the alarm setting. The combustibles readout should be fully recalibrated before using the instrument.

Replace the case top. Refer to Section 4.3.5.2 for replacement instructions.

The instrument should be fully recalibrated before it is used. Refer to Section 4.2 for calibration procedures.

4.3 REPLACEMENT OF MAJOR COMPONENTS

The sensors of the MX241 will require occasional replacement. The output of the oxygen sensor will gradually decline until it is no longer possible to calibrate the instrument. The combustible gas sensor will also experience a gradual loss of response. It may burn open a sensing bead, which will cause the instrument to go into a malfunction condition.

When either sensor needs to be replaced, refer to

the following procedures. Sensors should only be replaced by qualified repair technicians.

The battery pack of the MX241 may occasionally require replacement. The pack should last for at least 1000 charge/discharge cycles.

WARNING: THE USE OF ANY PACK OTHER THAN INDUSTRIAL SCIENTIFIC CORPORATION PART NUMBER 1702-4688, MAY DAMAGE THE INSTRUMENT AND **WILL** INVALIDATE ALL APPROVALS.

Apparent reductions in battery capacity may be the result of repeatedly using the instrument for a short period and then recharging. A fully charged battery pack that does not deliver power for eight hours of continuous monitoring may have developed a "memory" condition. To overcome this, the battery should be subjected to a deep discharge and then fully recharged. This should be repeated several times. If eight hours of operation cannot be obtained, then replace the battery pack.

4.3.1 PRELIMINARY INSTRUMENT DISASSEMBLY

To reach the sensors or the battery pack, the instrument must be partially disassembled. All replacement procedures should begin as described in this section. After preliminary disassembly, refer to the specific section covering the assembly that is being replaced.

4.3.1.1 Use the 5/64 hex key provided with the instrument to remove the 6-32 screws on either side of the instrument. Back off the knurled knob of the strap assembly as far as possible. Use a 5/16 nut driver to unscrew the center post of the strap assembly. The case top will now lift off of the instrument.

4.3.1.2 To avoid possible damage to the electronics, unsolder the buss wire connecting the on/off switch to eyelet E26 on the bottom left-hand corner of the mother board. Separating this wire from the switch will turn off the instrument. If the oxygen sensor is to be replaced, stop here and refer to Section 4.3.2. If the battery pack or combustibles sensor are to be replaced, continue with 4.3.1.3.

4.3.1.3 Remove the three screws holding the PC boards onto the instrument brackets. Take care not to lose the three spacers which set between the two boards and will be free once the screws are removed. The two boards will swing up and out to the right to reveal the assemblies in the case bottom.

4.3.2 OXYGEN SENSOR REPLACEMENT

Replacement oxygen sensors, ISC Part Number 1701-9282, may be obtained from the local distributor for Industrial Scientific Corporation.

They are shipped in a sealed bag to prevent aging of the oxygen cell by exposure to air. The seal should not be broken until the cell is about to be placed in the instrument.

4.3.2.1 Desolder the red sensor wire from eyelet E1 of the mother board and the black sensor wire from eyelet E30 of the auxiliary control board. Remove the old sensor and the adhesive foam pad between the old sensor and the oxygen block.

4.3.2.2 Take the new sensor out of its sealed bag. Solder the **RED** sensor wire into eyelet E1 of the mother board. Solder the **BLACK** sensor wire into eyelet E30 of the auxiliary control board.

4.3.2.3 Remove the protective paper from the foam pad on the face of the sensor. Taking care that the opening in the pad lines up with the opening in the oxygen sensor, press the new sensor into place. Note that the red tab at the front of the sensor must sit just above the edge of the display board for the sensor to seat properly.

4.3.2.4 Refer to Section 4.3.5 for instructions on reassembling the instrument.

4.3.3 COMBUSTIBLE SENSOR REPLACEMENT

Replacement combustible gas sensors, Part Number 1702-5172 may be obtained directly from Industrial Scientific Corporation or from the local distributor of Industrial Scientific products. They are shipped as a complete assembly, ready to be bolted into the instrument.

4.3.3.1 Remove the three screws which hold the bezel onto the beveled surface of the case bottom and remove the bezel. Note that the protective screens under the bezel will fall free when the bezel is removed.

4.3.3.2 Desolder the red, black, and white wires of the combustible sensor from eyelets E6, E7, and E8 of the mother board.

4.3.3.3 There will be four small screws visible on the beveled surface of the case bottom. Remove the two which are nearest the charging jack receptacle. This will free the old sensor. Take care not to misplace the small gasket found between the sensor and the case.

4.3.3.4 Solder the three wires of the new sensor into the mother board, entering from the non-component side. The **RED** wire goes to eyelet E6, the **WHITE** wire goes to eyelet E7, and the **BLACK** wire goes to eyelet E8. Place the sensor on the beveled surface of the case, making sure that the gasket is properly positioned between the sensor and the case. Attach the sensor using the two mounting screws that enter from the bezel side of the beveled surface.

4.3.3.5 Lay the three screens into their receptacles in the beveled surface. Lay the bezel over the screens and fasten the bezel with its three mounting screws.

4.3.3.6 Refer to Section 4.3.5 for instructions on reassembling instrument.

4.3.4 BATTERY PACK REPLACEMENT

CAUTION: DAMAGE MAY OCCUR TO THE INSTRUMENT IF COMPONENTS ARE SHORTED DURING THE FOLLOWING STEPS.

4.3.4.1 Desolder the red battery lead from eyelet E22 and the black battery lead from eyelet E21.

CAUTION: DAMAGE MAY OCCUR TO THE INSTRUMENT IF THE BATTERY LEADS ARE ALLOWED TO TOUCH THE PRINTED CIRCUIT BOARDS

4.3.4.2 The battery pack is held in the case by double-back foam adhesive. Care must be taken not to damage the earphone contacts in the bottom or distort the case while removing the damaged battery pack. Using a screwdriver, gently pry the pack out of the case bottom.

4.3.4.3 Any foam left in the case bottom **must** be removed before installing the new battery pack. Failure to do so may make the battery pack too high and interfere with the mother board.

4.3.4.4 Remove the protective cover from the adhesive foam on the bottom of the new pack. Carefully place the battery pack in the case bottom. The battery must be under the bottom bracket to insure sufficient room will be left for the small regulator board mounted on the bottom of the mother bo[illegible]

4.3.4.5 **DO NOT** allow the leads of the new batt[illegible] pack to touch each other or to touch any portion of the printed circuit boards while soldering the leads into place. Entering the mother board from the non-component side, solder the **RED** battery wire to eyelet E22 and the **BLACK** battery wire to eyelet E21.

4.3.4.6 Use a voltmeter to confirm that the voltage at eyelet E26 is negative with respect to the right-hand terminal (at eyelet 27) of the on/off switch. If it is not, an error has been made. Refer to Section 4.3.4.5 for the proper wiring connections.

4.3.4.7 Refer to Section 4.3.5 for instructions on reassembling the instrument.

4.3.5 REASSEMBLY OF THE INSTRUMENT

4.3.5.1 If the PC boards have been lifted to reach the battery pack or combustibles sensor, replace the mother board on the three mounting brackets, carefully laying the wiring service loops into the case bottom. Do not force the board down. Rework the service loops gently if there is difficulty replacing the board. Use the three mounting screws and three spacers to re-attach the display board/mother board assembly to the case bottom. Restore the connection from the on/off switch to eyelet E26 on the mother board.

4.3.5.2 Place the case top onto the instrument, making sure that it is properly seated all around in the gasket. Fasten the case together with the two 6-32 screws and the strap mounting post. Tighten the strap mounting post with a 5/16 nut driver before screwing the knurled collar back into place.

4.3.5.3 The instrument should be fully recalibrated before it is used. Refer to Section 4.2 for calibration procedures.

5.0 REPLACEMENT PARTS LIST

Item numbers refer to Figure 3 (Exploded View).

ITEM	DESCRIPTION	ISC Part No.
1	Case Bottom with Jack	1701-0935
2	Battery Pack, Potted, 750 mAH 4.8V	1702-4688
3	Screw, 4-40 x 1/4, Cross Recess, Flathead	1701-2378
4	Oxygen Adaptor Block	1701-7997
5	Oxygen Cell Plate	1701-7989
6	Buzzer Shock Mount Pad	1701-7922
7	Audio Indicator	1702-3896
8	Oxygen Sensor Assembly (See note Page 26)	1701-9282
9	Screw, Panhead, Nylon, 4-40 x 3/8	1700-8533
10	Washer, Molded, #4, Nylon	1701-8714
11	Oxygen Cell and Buzzer Cover	1701-8086
12	Detector Block Gasket	1701-0737
13	MX241 Detector Block Assy. (See note Page 26)	1702-5172
14	Screw, Cross Recess, Flathead, Undercut 2-56 x 1/4	1701-3566
15	Screw, Cross Recess, Flathead, Undercut 2-56 x 3/16	1701-9290
16	Screen, 10-200 mesh .422x861	1701-0646
17	Screen, 10-200 mesh, 1.032 dia.	1701-0653
18	Screen, 10-200 mesh, .313 dia.	1701-0661
19	Bezel	1701-0620
20	Screw, Cross Recess, Flathead, Undercut 2-56 x 1/8	1701-7914
21	Auxiliary Control Board Mounting Pad	1701-9084
22	Auxiliary Control Board Ass'y	1701-9076

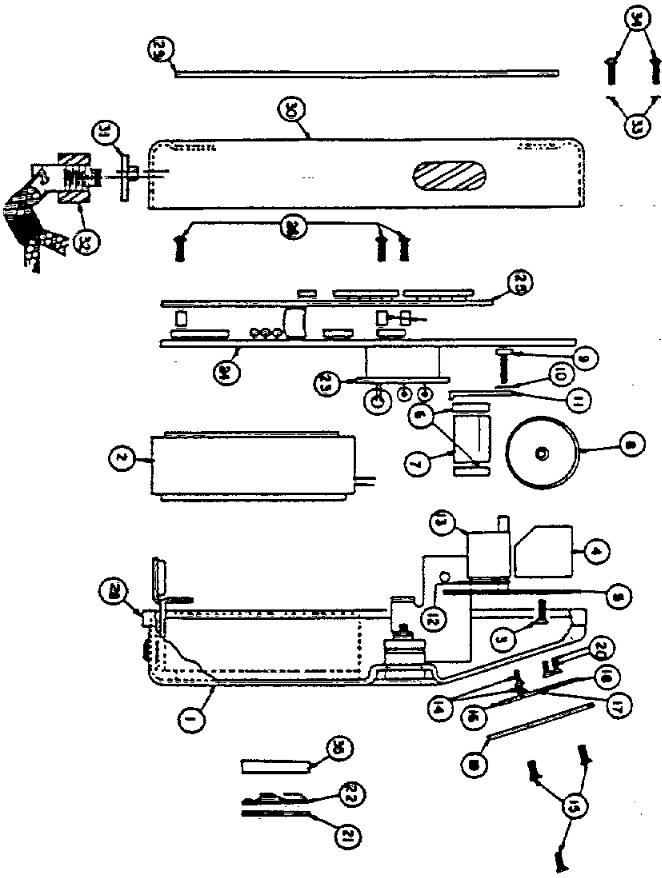

Figure 3.
Exploded View

Figure 3 Parts List (con't)

ITEM	DESCRIPTION	ISC Part No.
23	Switching Regulator Board Assembly	1702-4795
24	MX241 Mother Board Ass'y	1701-0786
25	Liquid Crystal Display Board Assembly	1701-0844
26	Screw, 4-40 x 3/8, Panhead, Stl. CP	1700-4540
27	Spacer, Nylon .188 x .116 ID x .203L	1701-0745
28	Gasket, Molded 200 Series	1702-4589
29	MX241 Faceplate	1702-5248
30	Case Top Assembly	1701-0885
31	Calibration Cover w/Pin	1700-5380
32	Strap Assembly	1700-4078
33	Washer, #6, Internal, Stainless Steel	1701-9787
34	Screw, Socket Buttonhead, 6-32 x 3/16, SST	1701-3558
35	Auxiliary Control Board Shielding Pad	1701-9746

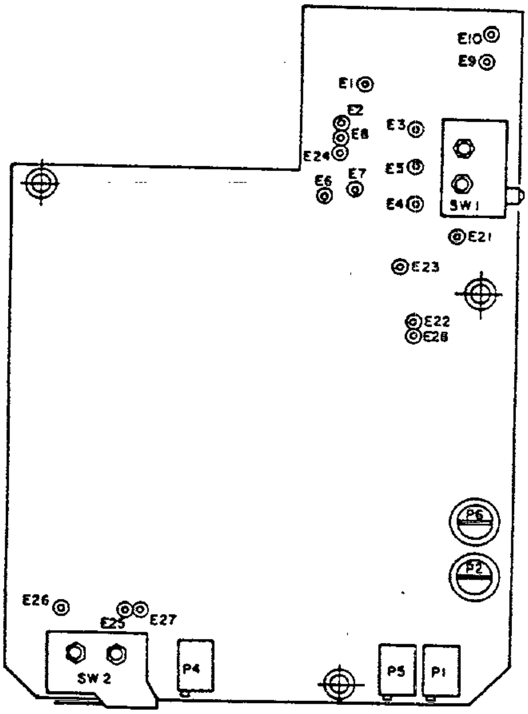

Figure 4.
MX Mother Board

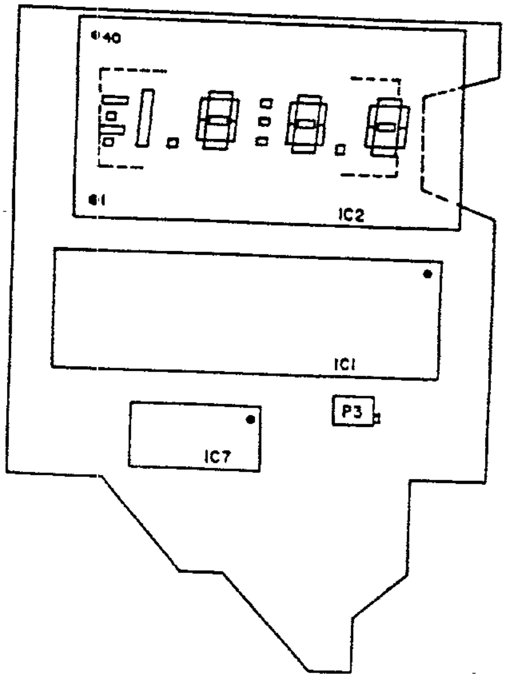

Figure 5.
MX Display Board

NOTE: The catalytic combustion sensor has a shelf life of several years when stored in a clean atmosphere at temperatures between -20°C and 55°C. The recommended storage temperature for the instrument and sensor is between -35°C and 40°C.

INDUSTRIAL
SCIENTIFIC

Model SP201
SAMPLING
PUMP

TABLE OF CONTENTS

1.0 Purpose of the Unit

At those times when it is disadvantageous or unsafe for the user of a gas measuring instrument to enter the area where an atmospheric determination is to be made, the SP201 (in conjunction with one of the National Mine Service Company 200 Series gas monitoring instruments) can be used for remote sampling.

2.0 Specifications

Dimensions: 52 mm x 79 mm x 137 mm
(2.04" x 3.1" x 5.4")

Weight: 312 grams (11.0 ounces)

Pump Capability: One (1) liter per minute (lpm) at 3.5" water back pressure through 30' of .160 ID hose. (Note: Maximum sampling length is 100 feet)

Battery Capacity: 500 mA hours

Battery Voltage: 4.8 (nominal)

3.0 Operation

WARNING: Before using the SP201, test the unit to insure that it is operating properly. A failure of internal hose integrity could cause inaccurate instrument readings due to failure to draw a proper sample. Test the pump by turning it on and and firmly seal the inlet port with your finger. The pump motor will be clearly heard at first but will then stop as it tries to pull a sample through the blocked inlet port. If the motor does not stall completely, the pump <u>must</u> be repaired before use.

NOTE: When operating the pump in particularly dusty areas, we recommend installing a piece of cotton, felt or other suitable filter material in the inlet port of the pump.

This will filter out small dust particles before they enter into the internal filter and will help prolong the life of the pump.

The cotton or filter material should be replaced daily.

Fit the SP201 over the sensor end of the 200 Series Instrument. The two should be fully and firmly coupled. There will be obvious gaps between the SP201 and the instrument: These are intentional and serve to prevent sensor pressurization. Screw the extendable probe into the SP201. Turn on the SP201. Allow one minute for the sampling line to be purged before reading the concentration.

If the pump motor is heard to stall or slow severely during use, there may be a blockage in the extendable probe. Unscrew the probe, clear the blockage, and check the unit as described above before resuming operation.

4.0 Maintenance

The SO201 requires no regular maintenance except for the recharging of its batteries and the periodic replacement of its internal filter. This small filter assembly inside the unit must be replaced when it becomes dirty or obstructed.

Inspect the SP201 periodically, especially after use in a particularly dusty of moist area. Op the case, verify the integrity of the internal connecting hoses, and determine whether the filter is clean and unobstructed.

If a new filter is needed, remove the entire section of tubing which holds the filter element. Replacement

filters will be auplied already installed inside a piece of replacement tubing which should be securely pressed over the fittings that held the old filter alssembly. As in Section 3.0, the pump motor should stall when the inlet port is blocked.

The batteries of the SP201 require 75 milliamperes of constant charging current. A completely discharged battery's full potential will be restored by 14 hours of charging. As with the gas measuring instruments, either the Single Unit or the Five Unit 200 Series Charger must be used. There is no danger of overcharging the batteries when using one of these chargers.

NOTE: The Pump <u>MUST</u> be turned off for it to be charged.

Apparent reduction in battery capacity may result from repetitive use patterns. Depending upon back pressure, a fully charged battery should be able to provide enough energy for 5 to 8 hours of continuous operation. A fully charged battery that does not provide enough energy for 5 to 8 hours of continuous operation may have developed a "memory" condition. To eradicate this, discharge the battery to 4.0 VDC, and then fully recharge the battery. The memory effect cand be avoided by using the SP201 so that the battery is discharged to varying depths.

5.0 Replacement Parts List

The following item numbers refer to Figure 1.

ITEM	DESCRIPTION	NMS P/N
1	Case Back w/Cal Cup	1700-7436
2	Bracket, Reifg, Pntd, SP201	1702-2146
3	Rivet, SST	1702-2245
4	Case, Front, w/ Liner	1700-7410
5	Battery Pack	1700-3831
6	Charging Socket	1700-1650
7	Solder Lug	1701-1990
8	Fitting, Cvrsn, Brs, SP201	1702-2120
9	Nut, Hex, 5/16-24, Stl Cp	1702-2237
10	Pump Assembly	1700-7576
11	Board, PC, Assembly, SP200	1701-2121
12	Screw, 2-56 x 3/16 SST	1701-3582
13	Tubing, .125 ID	1700-7592
14	Filter Assembly, SP200 Pump	1701-0539
15	Screw, 4-40 x 1/4 BH, Hxst SST	1701-3541
16	Washer, Lkg, Int #4 SST	1701-9795

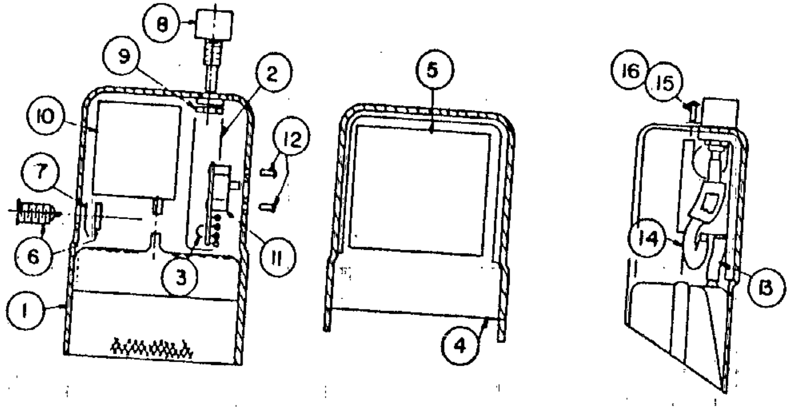

FIGURE 1
Exploded View

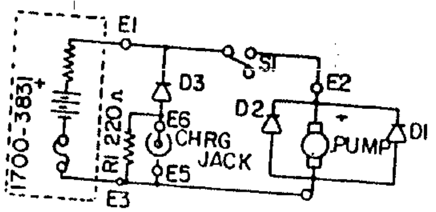

FIGURE 2
Schematic

APPENDIX H

NUS LSD PROCEDURES MANUAL

INORGANIC REQUIREMENTS FOR NON-HSL PARAMETERS

NUS **LABORATORY SERVICES DIVISION** **PROCEDURES MANUAL**	SECTION CLP-5.0	REVISIONS 0	EFFECTIVE DATE 10/30/86	PAGE 1 of 16
	TITLE Adaptation of CLP Inorganic Requirements to Analyses for Non-HSL Parameters			

1.0 REFERENCES

- USEPA Contract Laboratory Program, "Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, SOW No. 785," USEPA, 7/85.
- LSD laboratory procedures or other standard references (e.g., Standard Methods, EPA Methods for Chemical Analysis of Water and Wastes, Federal Register).
- LSD Procedure CLP-1.0, CLP Project Records
- LSD Procedure CLP-3.0, CLP Analysis, Data Review and Report Preparation

2.0 SCOPE

This procedure is to be used to analyze samples for non-HSL parameters according to CLP protocol, whenever it is referenced in a project work plan.

3.0 PRINCIPLE OF METHOD

See the appropriate LSD Procedure or standard reference.

4.0 INTERFERENCES

See the appropriate LSD Procedure or standard reference.

5.0 PROCEDURE

See the appropriate LSD Procedure or standard reference.

6.0 QUALITY CONTROL REQUIREMENTS

6.1 Calibration

System calibration (instrument calibration, titer standardization, or analysis of a standard curve) is to be performed as directed in the appropriate LSD Procedure or standard reference. The calibration should be performed when required by the method or to bring the recovery of an out-of-control calibration verification standard into control. (See 6.2.)

David Sommers 11/7/86 QA Coordinator - Clear Lake City Date	Lisa Manning 11-5-86 QA Coordinator - Pittsburgh Date	11-5-86 General Manager Date
Jerry W. Bright 11/7/86 Laboratory Manager - Clear Lake City Date	M J Marple 11-6-86 Laboratory Manager - Pittsburgh Date	

6.2 Calibration Verification

6.2.1 A calibration verification standard is a standard prepared from an EPA QC Standard (when available) or from the stock standard solution (when EPA QC Standard is not available). A calibration verification standard is to be analyzed at the beginning and end of of a run, and following every 10 analytical samples. (Blanks, duplicates, spikes, and samples all count as "analytical samples".) For analyses in which a distillation step is followed by a coloring step (as in phenol analyses), the verification standard is to be redistilled each time in order to verify the distillation process as well as the coloring process.

NOTE: If the preparation of a verification standard is difficult or excessively time-consuming (as for nitrite, residual chlorine, or sulfide), the calibration verification is not required unless otherwise stated in a project work plan.

6.2.2 The control limits for the percent recovery (%R) of the calibration verification are 85-115%. If the recovery of a verification standard is outside these limits, corrective action to yield acceptable recovery is required. In addition, all samples analyzed between the nonconforming verification standard and the previous acceptable verification standard must be reanalyzed. (If recovery was unacceptable because it was greater than 115%, samples with results below the detection limit do not need to be reanalyzed.)

6.3 Preparation Blank

6.3.1 A preparation blank is an aliquot of DI water taken through a preparation step or a series of preparation steps (such as distillation) prior to the determination of its analyte concentration.

6.3.2 A preparation blank is analyzed whenever a procedure has one or more preparation steps.

6.3.3 A preparation blank is to be analyzed for each set of samples prepared on the same day. If different matrices are prepared by separate procedures, a preparation blank for each matrix must be prepared and analyzed.

6.3.4 The blank must not contain the analyte at a concentration greater than the detection limit. If this limit is exceeded, all samples prepared with the out-of-control blank at a concentration less than ten times the detection limit and greater than the detection limit must be reanalyzed.

6.4 Duplicate

6.4.1 One in twenty samples of each matrix of a case is prepared and analyzed in duplicate. The same sample aliquot should be used for the original and duplicate determinations whenever sample volume or mass permits.

6.4.2 The control limits for the relative percent difference (RPD) of the duplicate analysis are 0-20 percent if the results are greater than five times the method detection limit. If the results are less than or equal to five times the method detection limit, the RPD control limit is ± the method detection limit.

$$RPD = \left| \frac{O-D}{(O+D)/2} \right| \times 100$$

Where:

O = Original result
D = Duplicate result

The control limits are advisory; corrective action is not required if the limits are exceeded. However, if a duplicate analysis exceeds the control limit, the results of all samples in a case of the same matrix as the out-of-control duplicate must be flagged with a star (*).

6.5 Matrix Spike

6.5.1 One in 20 samples of each matrix of a case is spiked prior to sample preparation with a known amount of standard for each parameter for which a stable standard solution is available. The sample aliquot used for the unspiked determinations should matrix spike aliquot whenever sample volume or mass permits.

6.5.2 The control limits for the percent recovery (%R) of the spike analysis are 75-125%.

$$\%R = \frac{SSR-OR}{SA} \times 100$$

Where:

SSR = Spiked sample result
OR = Original result
SA = Spike added

The control limits are advisory; corrective action is not required if the limits are exceeded. If the limits are exceeded, the results of all samples in a case of the same matrix as the out-of-control spike must be flagged with the letter "N." However, if the sample concentration exceeded the spike concentration by a factor of four or more, the spike recovery should not be considered and the results reported unflagged.

7.0 REAGENTS

See the appropriate LSD Procedure or standard reference.

8.0 APPARATUS

See the appropriate LSD Procedure or standard reference.

9.0 DOCUMENTATION

9.1 Documentation of the analysis of the samples must be made in a bound laboratory notebook. See Figures 1-5 for samples of the required documentation.

9.2 Non-HSL Parameters Forms I through V are completed to document sample results and applicable quality control data. (See Figures 6-10.)

- Form I

The results of samples analyzed for a particular parameter are recorded on Form I. Results of aqueous samples are reported in mg/L; results of solid samples are reported in mg/kg on a dry weight basis. (Multiply the mg/kg result of the wet analysis by 100 divided by the percent solids to express the result on a dry weight basis.)

Results are reported to two significant figures down to the detection limit.

Deviations from the procedure or any analytical problems encountered should be described under the "Comments" section. Any qualifiers used should also be identified in the "Comments" section. These include, but are not limited to, the following:

U - Analyte not detected
E - Analyte concentration estimated due to interference
s - Result determined by Method of Standard Additions
N - Spike sample recovery not within control limits
* - Duplicate analysis not within control limits

- Form II

The true value, the actual value, and the percent recovery of each calibration verification standard are recorded on Form II. The source of the verification standard (EPA QC Study number or manufacturer and lot number) is recorded at the bottom. (Use attachment if multiple sources will not fit in the space provided.)

- Form III

  The results of the preparation blank analyses are recorded on Form III. In addition, if a reagent blank is used to determine sample results, the value of the reagent blank is also recorded on Form III. The units should be indicated with each blank value (mg/L, abs, mls).

- Form IV

  The results of the spike analysis are recorded on Form IV.

- Form V

  The results of the duplicate analysis are recorded on Form V.

FIGURE 1

TITLE Total Organic Halogen

PROJECT NO. Name of Client-Project (e.g. NYSDEC-Avon)

BOOK NO. Four-digit number of book

45

DUPLICATE

Instrument- Dohrman TOX Box (1 or 2)

Stock Solution - manufacturer, lot no.

e.g Stock solution:

(Verification standard) prepared from stock (date)

e.g. 100 µg/L standard prepared from stock solution 10-22-85

EPA Reference Standard - list study, how prepared, true value

Sample No.	Aliq (ml)	Column 1 µg Cl	Column 2 µg Cl	Result µg/L	Precision
NO_3 wash					—
					—
Standard					—
					—
Sample					—
dup					
Sample					—
dup					

SIGNATURE Signature of Analyst

DATE Date Analyzed

DISCLOSED TO AND UNDERSTOOD BY Signature of Reviewer

DATE Date Reviewed

WITNESS

DATE

FIGURE 2

TITLE Total Organic Carbon, non-purgeable

PROJECT NO. Name of Client - Project (e.g. NYSDEC - Avon) 35

BOOK NO. Four-digit number of book

DUPLICATE

Instrument – DC-80

Stock Solution – manufacturer, lot no.

e.g. Stock Solution: $KC_8H_4O_4$ – NBS Standard

(Calibrating and verification standards) prepared from stock solution (date)

e.g. 400, 50, 10, and 5 mg/L TOC standards prepared from stock solution 10-22-85

EPA Reference Standard – list study, how prepared, true value

Calibration:

Baseline –

Deflection –

200µl injection			1.0 ml injection		
Std (mg/L)	Readout	% Recovery	Std (mg/L)	Readout	% Recovery
400		–	10		–
400		–	10		–
400		–	10		–
Average		–	Average		–
400			10		
50			5		

Sample no	Diln	Aliq	Vol	Spike Conc	Init. Conc	Result (mg/L)

Standard (list as concentration, e.g. 5 mg/L standard)

Samples

dup

spike

Precision = ⊖

Accuracy = ⊖

Standard curve used to calculate results - date

SIGNATURE

Signature of Analyst

DATE

Date Analyzed

DISCLOSED TO AND UNDERSTOOD BY

Signature of

DATE

Date

TITLE Name of Test
(for tests using millivolt meter)

FIGURE 3

PROJECT NO. Name of Client-Project (e.g. NHSDEC-Anon)

BOOK NO. Four-digit number of book

32

DUPLICATE

Meter-manufacturer and model no.

Stock Solution-manufacturer and lot no. of each component of stock (include compound(s), acid added, etc)
e.g. Stock Solution: anhydrous NH_4Cl - Fisher Scientific, Lot # 123456

(Calibrating and/or verification standards) prepared from stock (date)
e.g. 0.1, 0.5, 1.0, 10.0, and 100.0 mg/L NH_3-N standards prepared from stock solution 10-22-85

EPA Reference Standard - list study, how prepared, true value

Calibration:

Describe the calibration in an appropriate format (tabular, if possible) only if the data is not included with the standard curve on which the data is based (i.e. pH). List all standards used in the calibration. Indicate the readout of the check standards, if any.

(For sample analysis, use headings normally used on worksheets)
e.g. Fluoride

Sample no. Diln Aliq Init Conc. (mg/L) Result (mg/L)
Blank
Standard (list as concentration, e.g. 0.492 mg/L standard)
Samples
dup
spike

Precision = ⊖
Accuracy = ⊖

Standard curve used to calculate results - date, number(s) of curve (if more than one curve for day), factor(s)

ATURE
Signature of Analyst

DATE
Date Analyzed

DISCLOSED TO AND UNDERSTOOD BY
Signature of Reviewer

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DATE

Section	Title	Revision	Effective Date	Page
CLP-5.0	Adaptation of CLP Inorganics Requirements to Analyses for Non-HSL Parameters	0	10/30/86	10 of 16

FIGURE 4

TITLE Name of Test
(for colorimetric tests)

PROJECT NO. Name of Client – Project
(e.g. NYSDEC–Avon)
BOOK NO. Four-digit number of book

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DUPLICATE

Spectrophotometer-manufacturer, model no., spec no.
wavelength (nm)

Stock Solution-manufacturer and lot no. of each component of stock
(include compound(s), acid added, etc)
e.g. Stock Solution: Potassium dichromate ($K_2Cr_2O_7$) – NBS standard

(Calibrating and/or verification standards) prepared from stock solution (date)
e.g. 1.0 mg/L Cr^{+6} standard prepared from stock solution 10-22-85

EPA Reference Standard – list study, how prepared, true value

(For sample analysis, use headings normally used on worksheets)

e.g.

Sample no.	Diln	Aliq	Spike Vol	Conc	Cell	Abs	Net Abs	Result (mg/L)
Blank								
Standard (list as concentration, e.g. 1.0 mg/L standard)								
Samples								
dup								
spike								

Precision = ⊖
Accuracy = ⊖

Standard curve used to calculate results – date, number(s) of curve (if more than one curve run that day), factor(s)

SCIENTIFIC BINDERY PRODUCTS CHICAGO 60685

SIGNATURE Signature of Analyst	DATE Date Analyzed
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WITNESS	DATE

FIGURE 5

TITLE Name of Test
(for titration tests)

PROJECT NO. Name of Client- Project
(e.g. NYSDEC-Avon)

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BOOK NO. Four-digit number of book

DUPLICATE

Titer - manufacturer and lot no. of each component of titer
(include compounds(s), acid added, etc.)
e.g. $Hg(NO_3)_2$ - Fisher Scientific, Lot #123456

Components used to standardize titer - manufacturer and lot no. of each
e.g. KCl - NBS Standard

Sample No.	Diln	Aliq	Spike Vol	Spike Conc	ml Titer	Net ml	Result (mg/L)
Blank						—	—
Standard (list as concentration, e.g. 0.2 mg/L Standard)							
Samples							
dup							
spike							

Precision = ⊖
Accuracy = ⊖

Normality of Titer = (See standardization (data))

SIGNATURE Signature of Analyst

DATE Date Analyzed

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FIGURE 6

NON-HSL PARAMETERS

Form I

Date: ____________________

LAB NAME: NUS Corporation

CASE NO: ____________________

PARAMETER: ____________________

MATRIX: Water ______ Soil ______ Sludge ______ Other ______

mg/L or mg/kg (dry weight) or Other ________

NUS SAMPLE NO.	CLIENT SAMPLE NO.	RESULT

COMMENTS: ____________________

LAB MANAGER: ____________________

FIGURE 7

NON-HSL PARAMETERS
FORM II
CALIBRATION CHECK STANDARDS ①

LAB NAME NUS Corporation

CASE NO.

DATE

UNITS

	PARAMETER	TRUE VALUE	FOUND	% RECOVERY
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

① Calibration Check Standard Source

FIGURE 8

NON-HSL PARAMETERS
FORM III
BLANK

LAB NAME NUS Corporation

CASE NO.

DATE

MATRIX

	PARAMETER	BLANK VALUE
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		

① The blank value is from a method blank, an aliquot of DI water which undergoes the same analytical treatment as a sample except any distillation or digestion procedures. This value is subtracted from the sample value to obtain the net value used to calculate the sample result.

② The blank value is from a preparation blank, an aliquot of DI water which undergoes the same analytical treatment as a sample, including any distillation or digestion procedures.

FIGURE 9

NON-HSL PARAMETERS

Form IV

SPIKE SAMPLE RECOVERY

LAB NAME NUS Corporation

DATE ____________________

CASE NO. __________

CLIENT SAMPLE NO. __________

LAB SAMPLE ID NO. __________

UNITS __________

Matrix __________

Parameter	Spiked Sample Result (SSR)	Duplicate Result (DR)	Spiked Added (SA)	%R ①
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				

① %R = [(SSR − DR)/SA] x 100

"N" - out of control

Comments: ____________________

FIGURE 10

NON-HSL PARAMETERS

Form V

DUPLICATES

LAB NAME NUS Corporation

DATE ____________

CASE NO. ____________

CLIENT SAMPLE NO. ____________

LAB SAMPLE ID NO. ____________

UNITS ____________

Matrix ____________

Parameter	Control Limit①	Sample(S)	Duplicate(D)③	RPD②
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				
26.				
27.				

* Out of Control

① Control Limit = ± 20%

② $RPD = [|S - D| / ((S + D)/2)] \times 100$

NC - Non calculable RPD due to value(s) less than the detection limit

③ The duplicate result is based on an aliquot smaller than that used to obtain the sample result. This serves as a check on matrix effects.

APPENDIX I

NUS DETECTION LIMITS

ORGANIC COMPOUNDS

TABLE 5

CLEAN WATER MATRIX DETECTION LIMITS
ORGANIC COMPOUNDS

Parameter	Appendix IX	HSL	Priority Pollutants	Toxicity Characteristic Contaminants	Hazardous Waste Constituents with TCLP	Detection Limit (µg/L)
Volatile Compounds						
Acetone	X	X			X	10
Acrolein	X		X			100
Acrylonitrile	X		X	X		100
Benzene	X	X	X	X		5
Bromoform	X	X	X			5
2-Butanone (Methyl ethyl ketone)	X	X			X	10
Carbon tetrachloride	X	X	X	X	X	5
Carbon disulfide	X	X		X	X	5
Chlorobenzene	X	X	X		X	5
Chlorodibromoethane	X	X	X			5
Chloroethane	X	X	X			10
2-Chloroethyl vinyl ether	X	X	X			10
Chloroform	X	X	X	X		5
Dichlorobromomethane	X	X	X			5
1,1-Dichloroethane	X	X	X			5
1,2-Dichloroethane	X	X	X	X		5
1,1-Dichloroethylene	X	X	X	X		5
1,2-Dichloropropane	X	X	X			5
cis-1,3-Dichloropropylene	X	X	X			5
trans-1,3-Dichloropropylene	X	X				5
2-Hexanone	X	X				10
Ethylbenzene	X	X	X		X	5
Methyl bromide	X	X	X			10
Methyl chloride	X	X	X			10
Methylene chloride	X	X	X	X	X	5

TABLE 5

CLEAN WATER MATRIX DETECTION LIMITS
ORGANIC COMPOUNDS
PAGE TWO

Parameter	Appendix IX	HSL	Priority Pollutants	Toxicity Characteristic Contaminants	Hazardous Waste Constituents with TCLP	Detection Limit (µg/L)
4-Methyl-2-pentanone	X	X		X		10
1,1,2,2-Tetrachloroethane	X	X	X	X		5
Styrene	X	X				5
Tetrachloroethylene	X	X	X	X	X	5
Toluene	X	X	X	X	X	5
1,2-trans-Dichloroethylene	X	X	X			5
1,1,1-Trichloroethane	X	X	X	X	X	5
1,1,2-Trichloroethane	X	X	X	X		5
Trichloroethylene	X	X	X	X	X	5
Vinyl acetate	X	X				10
Vinyl chloride	X	X	X	X		10
Xylene, total	X	X			X	5
Acetonitrile	X					10
Allyl alcohol	X					100
2-Chloro-1,3-butadiene	X					5
3-Chloropropene	X					5
3-Chloropropionitrile	X					10
1,2-Dibromoethane	X					10
Dibromomethane	X					5
trans-1,4-dichloro-2-butene	X					5
Dichlorodifluoromethane	X					5
1,4-Dioxane	X					100
Ethyl cyanide	X					10
Ethyl oxide	X					10
Ethyl methacrylate	X					5
Iodomethane	X					5

TABLE 5

CLEAN WATER MATRIX DETECTION LIMITS
ORGANIC COMPOUNDS
PAGE THREE

Parameter	Appendix IX	HSL	Priority Pollutants	Toxicity Characteristic Contaminants	Hazardous Waste Constituents with TCLP	Detection Limit (ug/L)
Isobutyl alcohol	X			X	X	5
Pentachloroethane	X					10
2-Propyn-1-ol	X					3000
1,1,1,2-Tetrachloroethane	X			X		5
Trichloromethanethiol	X					10
Trichloromonofluoromethane	X				X	5
1,2,3-Trichloropropane	X					5
n-Butyl alcohol					X	ND
Cyclohexanone					X	ND
Ethyl acetate					X	ND
Ethyl ether					X	ND
Methyl isobutyl ketone					X	5
1,1,2-Trichloro-1,2,2-trifluoroethane					X	ND
Methanol					X	750
Acid Compounds						
2-Chlorophenol	X	X	X			10
2,4-Dichlorophenol	X	X	X			10
2,4-Dimethylphenol	X	X	X			10
4,6-Dinitro-o-cresol	X	X	X			50
2,4-Dinitrophenol	X	X	X			50
2-Nitrophenol	X	X	X			10
4-Nitrophenol	X	X	X			50
p-Chloro-m-cresol	X	X	X			10
Pentachlorophenol	X	X	X	X	X	50
Phenol	X	X	X	X		10

TABLE 5
CLEAN WATER MATRIX DETECTION LIMITS
ORGANIC COMPOUNDS
PAGE FOUR

Parameter	Appendix IX	HSL	Priority Pollutants	Toxicity Characteristic Contaminants	Hazardous Waste Constituents with TCLP	Detection Limit (µg/L)
2,4,6-Trichlorophenol	X	X	X	X	X	10
2-Methylphenol	X	X		X		10
4-Methylphenol	X	X		X		10
2,4,5-Trichlorophenol	X	X			X	50
2,6-Dichlorophenol	X					10
2,3,4,6-Tetrachlorophenol	X			X	X	10
3-Methylphenol				X		10
2,4,5-Trichlorophenol				X		10
2-sec-butyl-4,6-dinitrophenol	X					20
Base-Neutral Compounds						
Acenaphthene	X	X	X			10
Acenaphthylene	X	X	X			10
Aniline	X					10
Anthracene	X	X	X			10
Benzidine	X		X			50
Benzo (a) anthracene	X	X	X			10
Benzo (a) pyrene	X	X	X			10
Benzoic acid	X	X				50
3,4-Benzofluoranthene	X	X	X			10
Benzo (ghi) perylene	X	X	X			10
Benzo (k) fluoranthene	X	X	X			10
Benzyl alcohol	X	X				10
bis (2-Chloroethoxy) methane	X	X	X			10
bis (2-Chloroethyl) ether	X	X	X	X		10
bis (2-Chloroisopropyl) ether	X	X	X			10
bis (2-Ethylhexyl) phthalate	X	X	X			10

TABLE 5

CLEAN WATER MATRIX DETECTION LIMITS
ORGANIC COMPOUNDS
PAGE FIVE

Parameter	Appendix IX	HSL	Priority Pollutants	Toxicity Characteristic Contaminants	Hazardous Waste Constituents with TCLP	Detection Limit (µg/L)
4-Bromophenyl phenyl ether	X	X	X			10
Butylbenzyl phthalate	X	X	X			10
2-Chloronaphthalene	X	X	X			10
4-Chloroaniline	X	X				10
4-Chlorophenyl phenyl ether	X	X	X			10
Chrysene	X	X	X			10
Dibenzo (a,h) anthracene	X	X	X			10
dibenzofuran	X	X				10
1,2-Dichlorobenzene	X	X	X	X	X	10
1,3-Dichlorobenzene	X	X	X			10
1,4-Dichlorobenzene	X	X	X	X		10
3-3 Dichlorobenzidine	X	X	X			20
Diethyl phthalate	X	X	X			10
Dimethyl phthalate	X	X	X			10
Di-n-butyl phthalate	X	X	X			10
2-Nitroanaline	X	X				50
3-Nitroaniline	X	X				50
2,4-Dinitrotoluene	X	X	X	X		10
2,6-Dinotrotoluene	X	X	X			10
Di-n-octyl phthalate	X	X	X			10
1,2-Diphenylhydrazine (as azobenzene)	X		X			10
Fluoranthene	X	X	X			10
Fluorene	X	X	X			10
Hexachlorobenzene	X	X	X	X		10
Hexachlorobutadiene	X	X	X	X		10
Hexachlorocyclopentadiene	X	X	X			10

TABLE 5

CLEAN WATER MATRIX DETECTION LIMITS
ORGANIC COMPOUNDS
PAGE SIX

Parameter	Appendix IX	HSL	Priority Pollutants	Toxicity Characteristic Contaminants	Hazardous Waste Constituents with TCLP	Detection Limit (µg/L)
Hexachloroethane	X	X	X	X		10
Indeno (1,2,3-cd) pyrene	X	X	X			10
Isophorone	X	X	X			10
2-Methylnaphthalene	X	X				10
Naphthalene	X	X	X			10
Nitrobenzene	X	X	X	X	X	10
N-Nitrosodimethylamine	X		X			10
N-Nitrosodi-n-propylamine	X	X	X			10
N-Nitrosodiphenylamine	X	X				10
Phenanthrene	X	X	X			10
Pyrene	X	X	X			10
Pyridine	X		X			5
1,2,4-Trichlorobenzene	X	X	X			10
4-Nitroaniline	X	X				10
Acetophenone	X					10
2-Acetylaminofluorene	X					10
4-Aminobiphenyl	X					10
Benzenethiol	X					10
2-Picoline	X					10
p-Benzoquinone	X					10
Dibenzo (a,e) pyrene	X					10
Dibenzo (a,h) pyrene	X					20
Dibenzo (a,i) pyrene	X					10
3,3'-Dimethoxy-benzidine	X					50
p-Dimethylaminoazobenzene	X					10
7,12-Dimethylbenzo (a) anthracene	X					10
3,3'-Dimethylbenzidine	X					50

TABLE 5

CLEAN WATER MATRIX DETECTION LIMITS
ORGANIC COMPOUNDS
PAGE SEVEN

Parameter	Appendix IX	HSL	Priority Pollutants	Toxicity Characteristic Contaminants	Hazardous Waste Constituents with TCLP	Detection Limit (µg/L)
Alpha, alpha-dimethyl-phenethylamine	X					10
p-Dinitrobenzene	X					10
Diphenylamine	X					10
Hexachlorodibenzo-p-dioxins	X				X	ND
Hexadichlorodibenzofurans	X				X	ND
Hexachlorophene	X					1000
Hexachloropropene	X					10
Isosafrole	X					10
Malonitrile	X					5
Methapyrilene	X					10
3-Methylcholanthrene	X					10
4,4'-Methylene-bis-(2-chloroaniline)	X					50
Methyl methanesulfonate	X					50
1,4-Naphthoquinone	X					10
1-Naphthylamine	X					10
2-Naphthylamine	X					10
N-Nitrosodi-n-butylamine	X					10
N-Nitrosodiethylamine	X					10
N-Nitrosomethylethylamine	X					10
N-Nitrosomorpholine	X					10
N-Nitrosopiperidine	X					10
N-Nitrosopyrrolidine	X					10
5-Nitro-o-toluidine	X					10
Pentachlorobenzene	X					10
Pentachlorodibenzo-p-dioxins	X				X	ND
Pentachlorodibenzofurans	X				X	ND

TABLE 5
CLEAN WATER MATRIX DETECTION LIMITS
ORGANIC COMPOUNDS
PAGE EIGHT

Parameter	Appendix IX	HSL	Priority Pollutants	Toxicity Characteristic Contaminants	Hazardous Waste Constituents with TCLP	Detection Limit (ug/L)
Pentachloronitrobenzene	X					5
Phenacetin	X					10
Resorcinol	X					10
Safrole	X					10
1,2,4,5-Tetrachlorobenzene	X					10
2,3,7,8-Tetrachlorodibenzo-p-dioxin	X		X		X	0.1
Tetrachlorodibenzofurans	X				X	ND
Tris (2,3-dibromopropyl) phosphate	X					200
Pesticides/Polychlorinated Biphenyls (PCBs)						
Aldrin	X	X	X			0.05
Arochlor 1016	X	X	X			0.5
Arochlor 1221	X	X	X			0.5
Arochlor 1232	X	X	X			0.5
Arochlor 1242	X	X	X			0.5
Arochlor 1248	X	X	X			0.5
Arochlor 1254	X	X	X			1.0
Arochlor 1260	X	X	X			1.0
alpha-BHC	X	X	X			0.05
beta-BHC	X	X	X			0.05
delta-BHC	X	X	X			0.05
gamma-BHC (lindane)	X	X	X	X		0.05
Chlordane	X	X	X	X		0.5
Chlorobenzilate	X					5
4,4' DDD	X	X	X			0.10
4,4' DDE	X	X	X			0.10
4,4' DDT	X	X	X			0.10

TABLE 5
CLEAN WATER MATRIX DETECTION LIMITS
ORGANIC COMPOUNDS
PAGE NINE

Parameter	Appendix IX	HSL	Priority Pollutants	Toxicity Characteristic Contaminants	Hazardous Waste Constituents with TCLP	Detection Limit (µg/L)
Dieldrin	X	X	X			0.10
0,0-diethyl-0-2-pyrazinyl phosphorothioate	X					10
Disulfoton	X					10
Endosulfan sulfate		X	X			0.10
alpha-Endosulfan	X	X	X			0.05
beta-Endosulfan	X	X	X			0.10
Endrin	X	X	X	X		0.10
Endrin aldehyde	X		X			0.10
Endrin ketone		X				0.10
Famphur	X					10
Heptachlor	X	X	X	X		0.05
Heptachlor epoxide	X	X	X			0.05
Isodrin	X					5
Kepone	X					5
Methoxychlor	X	X		X		0.5
Methyl parathion	X					10
Parathion	X					10
Phorate	X					10
Pronamide	X					10
Toxaphene	X	X	X	X		1.0
Tetraethyldithio-pyrophosphate	X					10
Herbicides						
2,4-Dichlorophenoxy-acetic acid	X			X		1.3
Silvex	X			X		1.3
2,4,5-T	X					1.3

ND - Not Determined